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Sitting time in young children at childcare: Prevalence, health consequences and intervention effects

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SITTING TIME IN YOUNG CHILDREN AT CHILDCARE:
Prevalence, health consequences, and intervention effects

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Certification

I, Yvonne Georgina Ellis, declare that this thesis, submitted in fulfilment of the requirements for the award of doctor of Philosophy, in the faculty of Social Sciences, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not yet been submitted for qualifications at any other academic institution.

Yvonne Georgina Ellis

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Acknowledgements

What a journey! On February 1st, 2013, I arrived in Wollongong to start an internship as part of my master Human Movement Sciences at Maastricht University. I was welcomed to the research group by my supervisor Tony Okely. Six months went by very quickly, and so I applied for a PhD scholarship hoping to extend my research experience. On the 1st of March, 2014 I returned to Wollongong to start my PhD journey, now four and half years later the PhD is approaching to an end. But this journey could not have happened with the help and support of my supervisors, colleageus, friends and family. Firstly, I would like to thank my supervisors, Tony Okely and Dylan Cliff, for their guidance and mentorship over the past five years. During this candidature they have giving me the opportunity to do this PhD, and gave me the professional support and opportunities to broaden my knowledge as a researcher.

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Preface

This candidate was involved collaboratively with my supervisors in this research project. More explicitly, the literature review as well as the design, the experiments, data analysis have been done with the assistance of my supervisors and co-authors, and data collection personnel. Where people other than this candidate, were involved in implementing or evaluating the interventions their involvement is noted throughout this thesis (e.g., data collectiors, researchers). Particularly, this candidate's involvement included: liasing with early childhood education and care centres, organising all equipment, organising necessary assistance (e.g., data collectors), performing the experiments, implementing the intervention, conducting data collection and providing training for data collectors, entering data, interpreting, analsysing and reporting the data, and writing this thesis. Contributions from other researchers were acknowledged by including their names as co-authors in the studies, see Appendix O. In agreement with my supervisors, this thesis has been prepared in journal article compilation style using APA (6th Edition, 2009) format.

Abstract

The overall purpose of this Doctorate was to conduct a number of studies to add to the evidence-base in the area of sedentary behaviour and health in young children (1-5 years) and potentially make an important contribution to improving the health and wellbeing outcomes for children by promoting best practice in childcare centres. This Doctorate comprises a literature review and four papers from four studies and addresses several gaps in the literature regarding sedentary behaviour in young children.

The first study examined total sitting, standing and physical activity time, socio-demographic distribution and compliance with both the Institute of Medicine (IOM) sedentary behaviour and physical activity recommendations among 301 young children (1 to 5years) from 11 childcare centres. In the sample, young children spent almost half of their time at childcare sitting. Pre-schoolers and girls spent significantly more time sitting and were less likely to meet sedentary behaviour recommendations compared to toddlers and boys.

The second study identified educators' perceptions of what environmental and policy modifications could be made within childcare settings to reduce sitting time among children during childcare. Educators identified that childcare practices, the physical environment and the weather were factors that influenced children's sitting time. Potential solutions were to break up prolonged sitting time by using movement-breaks, standing desks, movement transitions between activities, relocating key facilities around the space to promote movement, and integrating movement during learning activities.

The third study used the potential solutions developed by educators from the previous study to examine the acute effects of a “sit less, stand and move more” pre-school day on executive function and musculoskeletal health in pre-school aged children. The study also examined if there were any compensatory effects made by pre-school aged children on energy expenditure and energy intake as a result of a modified “sit less, stand and move more” pre-school day. This study found that replacing sitting time with standing was unlikely to result in changes in executive function and musculoskeletal health over an acute period of time among young children. No compensatory effects were found.

The findings from Studies 1-3 informed the development of Study 4. This study examined the feasibility, acceptability and potential efficacy of a childcare-based intervention to reduce total and prolonged sitting time in pre-schoolers. This study involved four centres and 115 pre-schoolers who participated in a 12-week, 2-arm pilot cluster randomized controlled trial. Feasibility and acceptability were assessed through observations and semi-structured interviews. Sitting time, breaks and bouts of sitting during childcare were assessed using an activPAL over a one-week period at pre- and post-test (12 weeks). Modifications to the childcare environment to reducing sitting, particularly the standing workstations, were feasible and acceptable to educators and pre-schoolers. No differences in sitting time between groups were seen.

To conclude, the findings from this Doctorate contributed to the evidence-base in the area of sedentary behaviour and health in young children. These findings provide important implications for the development of future interventions to reduce young children’s sitting time to optimise young children’s health and well-being.

Publications from the thesis

Chapter 3

Ellis, Y. G., Cliff, D. P., Janssen, X., Jones, R. A., Reilly, J. J. & Okely, A. D. (2016) Sedentary Time, Physical Activity and Compliance with IOM Recommendations in Young Children at Childcare. *Preventive Medicine Reports,* 7, 221-226.

Chapter 4

Ellis, Y.G., Cliff, D.P., Okely, A.D. (2017) Childcare educator's perceptions of and solutions to reducing sitting time in young children: a qualitative study. *Early Childhood Education Journal, 46*(4), 377–385.

Chapter 5

Ellis, Y.G., Cliff, D.., Howard, S.J., Okely, A.D. (2018). The acute effects of a 'reduced sitting pre-school day' on executive function and musculoskeletal health in pre-schoolers: a randomized cross-over study. Submitted to *Journal of Science and Medicine in Sport.*

Chapter 6

Ellis, Y.G., Cliff, D.P., Howard, S.J., Okely, A.D. (2018) Feasibility, acceptability, and potential efficacy of a childcare based intervention to reduce sitting time among pre-schoolers: A pilot randomized controlled trial. *Journal of Sport Sciences,* 1-10. DOI: 10.1080/02640414.2018.1486362

This study was funded by a faculty research grant by The University of Wollongong. The funders of the study had no role in the: design and conduct of the study; collection, management, analysis, or interpretation of the data; preparation, review, or approval of the manuscripts, and; decision to submit the manuscripts for publication.

Chapter 1:

General Introduction

The early years, which broadly encompass birth to five years, are considered one of the critical developmental periods in which health behaviours, such as physical activity and sedentary behaviour are established (Certain & Kahn, 2002; Ward, Vaughn, McWilliams, & Hales, 2010). Sedentary behaviour can be defined as any waking activity characterized by an energy expenditure of ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture (Tremblay et al., 2017). Sedentary behaviours are considered distinct and independent from physical activity behaviours of various intensities >1.5 METs (i.e., light- moderate- and vigorous intensity) (Salmon, Tremblay, Marshall, & Hume, 2011). However, young children, who are typically considered the most active group in the population, appear to have become more sedentary in the past 50 years (Okely, Salmon, Trost, & Hinkley, 2008). It has been reported that, on average, young children spend approximately 66% of their waking time sedentary (Hnatiuk, Salmon, Hinkley, Okely, & Trost, 2014), and that this behaviour tracks at a moderate level from early childhood (ages 3-5) to childhood (ages 5-8) (Jones, Hinkley, Okely, & Salmon, 2013). However, inconsistencies and limitations in methodologies means that further evidence is needed to determine the prevalence of sedentary behaviour in young children.

Spending prolonged periods of time sedentary, independent of the amount of moderate- to vigorous-intensity physical activity (MVPA) undertaken, has shown to be negatively associated with health outcomes in adults, such as cardiovascular disease, the metabolic syndrome, musculoskeletal disorders, and cognitive and brain health (Daneshmandi, Choobineh, Ghaem, & Karimi, 2017; de Rezende, Lopes, Rey-López, Matsudo, & do Carmo Luiz, 2014; Hamilton, Healy, Dunstan, Zderic, & Owen, 2008; Owen, Healy, Matthews, & Dunstan, 2010; Tremblay, Colley, Saunders, Healy, & Owen, 2010; Voss, Carr, Clark, & Weng, 2014). In children and adolescents, some studies suggest that independent of the amount MVPA undertaken, prolonged sedentary behaviour may be negatively associated with health outcomes, such as adiposity, insulin resistance, academic performance and cognitive development (Cliff et al., 2014; Cliff et al., 2013; Mitchell, Pate, Beets, & Nader, 2012; Saunders et al., 2013; Tremblay et al., 2011). However, when adjusting for time spent in MVPA, limited evidence shows that sedentary behaviour is independently associated with health in children (Cliff et al., 2016). In young children, even less evidence exists on the associations between sedentary time and health outcomes, including adiposity, cardiometabolic health, bone and skeletal health, and cognitive development (Poitras et al., 2017). The early years are a key developmental period for cognition, as this is where executive functions (EF) develop rapidly. EF include inhibition, cognitive flexibility, and working memory. These are strong indicators of school readiness and a better predictor of academic achievement than IQ (Blair & Razza, 2007). Currently, there are no studies testing the impact of reducing sitting on EF in young children.

Given the emerging evidence showing that sedentary behaviour may be negatively associated with health in children (Cliff et al., 2016; LeBlanc et al., 2012; Poitras et al., 2017), government authorities and professional organisations have acknowledged the importance of recommending limiting prolonged sitting time in young children. Recently released Australian 24-hour movement guidelines for the early years state that for sedentary behaviour, toddlers and pre-schoolers should not be restrained for more than 1 hour at a time (e.g., in a stroller, car seat or high chair) or sit for extended periods (Okely et al., 2017). Given that a large proportion (80%) of 3-4 year olds and around one-third of 1-2 year olds spend some time in childcare each week (OECD – Organization for Economic Cooperation and Development, 2014), the Institute of Medicine (IOM) have specifically developed sedentary behaviour recommendations for young children at childcare (Institute of Medicine, 2011).

The IOM state that the amount of time toddlers and pre-schoolers spend sitting or standing still at childcare should be limited to less than 30 minutes. Standing still has been included in this recommendation, although it is technically not a sedentary behaviour.

As the enrolment rates of young children attending childcare are high, childcare environments have a strong influence on many children's learning, development and behaviours that will promote health throughout their life (Ward, Vaughn, McWilliams, & Hales, 2009). Therefore, childcare centres represent an ideal setting to reduce sedentary behaviour and encourage active behaviour among this age group. There are, however, several gaps in the evidence base related to sedentary behaviour in the early years and specifically in childcare centres. For example, although valid, objective measures of sitting posture are now available, there are no studies that have used these measures to describe the total volume and patterns of sedentary behaviour during childcare, nor to understand possible factors associated with these behaviours. Further, there are no experimental studies investigating the effects of reducing sedentary behaviour among young children to understand acute or chronic health benefits. Finally, despite childcare being a key setting for targeting movement behaviours, there is only one other randomized controlled trial of an environmental intervention specifically targeting reductions in young children's sedentary behaviour while at childcare (De Craemer et al., 2016). The purpose of this thesis was to conduct a program of research to address these limitations in the evidence base.

1.1 Aim

The overall aim of this Doctorate was to conduct a suite of studies to strengthen the evidence-base related to sedentary behaviour in children aged 1 to 5 years. This PhD consists of five specific aims:

1. To examine the prevalence and socio-demographic distribution of sitting (standing and stepping time) among children aged 1 to 5 years whilst in childcare.
2. To understand early childhood educators' perceptions of young children's sitting time in childcare, the potential factors that contribute to high levels of sitting and potential modifications that could be made within childcare centres to reduce total and prolonged sitting among children during childcare.
3. To use the potential modifications to reduce sitting time in pre-schoolers formulated by childcare educators to examine the acute effects of a 'sit less, stand and move more' pre-school day on energy expenditure, musculoskeletal health, and executive function in pre-school aged children.
4. To examine if there are acute compensatory effects made by pre-school aged children following a modified "sit less, stand and move more" pre-school day in relation to energy expenditure and energy intake.
5. To conduct a pilot randomized controlled trial in childcare settings to examine the feasibility, acceptability, and potential efficacy of a 3-month childcare-based intervention to reduce sitting time among pre-schoolers, and to assess whether a reduction in sitting time has an effect on executive function.

1.2 Research questions

This Doctoral project investigated the following research questions:

1. What proportion of time do young children aged 1 to 5 years spend sitting, standing and stepping at childcare centres?
2. Does the proportion of time spend sitting, standing and stepping time vary by sex, age, weight-status and socio-economic status in young children at childcare?

3. How many breaks in sitting time and bouts of sitting time do young children accumulate at childcare and do these vary by demographic characteristics?
4. What proportion of young children comply with the IOM recommendation for sedentary behaviour and physical activity at childcare?
5. What are educator's perceptions of the amount of time children spend sitting in childcare centres?
6. According to educators, what factors may contribute to children's sitting time in childcare centres?
7. According to educators, what are the potential solutions to reduce children's sitting time in childcare centres?
8. What are the acute effects of a "reduced sitting pre-school day" on energy expenditure, executive function and musculoskeletal health in pre-schoolers?
9. Do children compensate in the 48 hours immediately after a "reduced sitting pre-school day" by increasing their energy intake or decreasing their energy expenditure?
10. What is the feasibility, acceptability and potential efficacy of childcare-based intervention to reduce sitting time among pre-schoolers.
11. Does a reduction in sitting time at childcare have an effect on executive function in young children?

1.3 Overview of thesis

This thesis includes a literature review, four original research studies reported in separate chapters, a general discussion, and conclusions. Three of the original research studies have been accepted for publication in peer-reviewed journals (Chapters 3, 4 and 6), and Chapter 5 has been submitted for publication in a peer-reviewed journal.

Chapter 2 reviews the literature, highlighting the need for the series of studies conducted as part of this thesis. It describes the definitions and summarizes the current evidence among young children regarding the patterns of sedentary behaviours, the relationship between sedentary behaviour and health outcomes, the measurement of sedentary behaviour, correlates of sedentary behaviour and interventions to reduce sedentary behaviour. The subsequent paragraph describes summarises the gaps in the literature and highlights the evidence required to address these gaps. This information is used to justify the aims of this thesis.

The third Chapter of this thesis addresses Aim 1 and answer research questions 1 to 4 by describing the sitting patterns of young children while at childcare. To determine the proportion of sitting time in young children, the amount of time young children spent sitting, standing and stepping was objectively assessed using the thigh-mounted activPAL monitor, which is able to accurately distinguish between sitting and standing. Furthermore, the frequency of sitting breaks and bouts in young children are reported. Chapter 3 also reports on children's compliance with the IOM physical activity and sedentary behaviour recommendations within childcare centres. Finally, socio-demographic differences in children's sedentary behaviour outcomes are investigated. These outcomes will be assessed for socio-demographic differences.

Chapter 4 addresses Aim 2 and presents the results of a qualitative study examining educators' perspectives of the factors that may influence sitting time in childcare centres. It furthermore provides their perceptions of potential solutions for reducing children's sitting time, which is important as it may inform the development of effective and solution-oriented interventions for decreasing sitting time among young children (De Decker et al., 2013; Robinson & Sirard, 2005). This chapter will answer research questions 5 to 8.

Based on the potential solutions to reduce sitting time in pre-schoolers formulated by the childcare educators in Chapter 4, Chapter 5 addresses Aims 3 and 4, and research questions 8 to 10 by presenting evidence on the acute effects of reducing sitting time on health outcomes in pre-schoolers. More specifically, the acute effects of a “sit less, stand and move more” pre-school day on executive function and musculoskeletal health are examined in pre-schoolers in a replicated childcare setting. The Chapter furthermore addresses compensatory effects on energy expenditure and energy intake as a result of a modified “sit less, stand and move more” pre-school day.

Chapter 6 addresses Aim 5, and research questions 11 and 12 by examining the feasibility, acceptability and potential efficacy of a childcare-based intervention to reduce total and prolonged sitting time in pre-schoolers. This pilot cluster-randomized controlled trial also assessed whether a reduction in children’s sitting time had an effect on executive function.

The six Chapters are followed by a general discussion and conclusion Chapter. This Chapter includes a summary of the key findings, overall strengths and limitations, implications and directions for future research.

1.4 Significance

Given that sedentary behaviours are established at a young age and have shown to track into childhood (Jones et al., 2013), it is important to conduct research to understand this behaviour in young children. Accumulating evidence is showing the associated health risks among children, however the health risks in young children are still unclear. Currently, young children have been reported to spend approximately 66% of their day sedentary (Hnatiuk et al., 2014). Since a large proportion of young children spend a considerable amount of time at childcare (OECD - Organization for Economic Cooperation and Development, 2014), this environment has an important influence in creating healthy habits and therefore might be a key setting to intervene.

This suite of studies aims to address the proportion of time spent sitting among young children during their time at childcare. In addition, it is not known if making simple modifications to the childcare environment results in more favourable health and developmental outcomes and whether educators can feasibly implement these modifications in a childcare setting.

1.4 Delimitations

This study was delimited in the following manner:

1. Participants were aged 1 to 5 years in the first study and 3 to 5 years in the third and fourth study. Participants were enrolled in the participating childcare settings on the days of data collection and the intervention.
2. Participating childcare centres were drawn from one childcare organisation in NSW, Australia.
3. Sitting time was assessed by the activPAL, collecting at least one day of data from each participant during childcare hours.
4. Executive functions were examined using the validated Early Years Toolbox assessment battery (Howard & Melhuish, 2017).
5. Musculoskeletal health assessments were assessed using validated, specific tests for flexibility, strength and balance suggested by physiotherapists.

6. The sedentary behaviour reduction intervention focused on reducing and breaking up sitting time in young children at childcare through professional development of childcare educators, and the implementation of standing desks and modified routine activities.

1.5 Limitations

The limitations of this project are noted below:

1. The primary outcome of Chapter 5 was energy expenditure, however due to technical problems with the data collected using whole-room calorimetry, the raw data was not available to analyse. Therefore, the main outcomes of the study are executive function and musculoskeletal health.
2. Toddlers were too young to comply with the instructions from the research assistant in the calorimeter room, therefore only pre-schoolers were recruited.
3. The intervention only included pre-school aged children (3 to 5 years) as the intervention was conducted in childcare rooms that catered for pre-school aged children.

1.6 Definition of terms

- *Accelerometer:* An instrument designed to measure time-varying differences in force or acceleration, used for physical activity assessments (Cliff, Reilly, & Okely, 2009)
- *BMI:* Body Mass Index, defined as weight in kilograms divided by height in metres squared (weight (kg)/Height[m]^2) (Cole, Bellizzi, Flegal, & Dietz, 2000)
- *Executive Function (EF):* A set of higher-order cognitive processes involved in goal-directed, flexible, and adaptive behaviour triggered in challenging, novel, and complex situations. Executive functions include cognitive flexibility, inhibition, shifting, and

working memory. They develop throughout childhood and adolescence, playing an important role in children's cognitive functioning, behaviour, emotional control and social interactions (Anderson, 2002; Miyake et al., 2000)

- *Moderate to Vigorous Physical Activity (MVPA):* Physical activity that is at least 4.0 times greater than the intensity of rest (Centres for Disease Control and Prevention, 2017).
- *Physical activity (PA)*: Bodily movement that is produced by contraction of the skeletal muscle and that substantially increases energy expenditure (Bouchard, Shephard, & Stephens, 1994).
- *Pre-school children*: Children aged between 3 and 5 years.
- *Sedentary behaviour (SB):* Sedentary behaviour can be defined as any waking activity characterized by an energy expenditure of ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture (Tremblay et al., 2017).
- *Toddlers:* Children aged between one and less than 3 years.
- *Young children:* Children aged between one and 5 years.

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Chapter 2:

Literature Review

This chapter is structured according to the Behavioural Epidemiology Framework (Sallis, Owen, & Fotheringham, 2000) to review and evaluate the literature on sedentary behaviour in young children. This chapter will define sedentary behaviour, followed by a summary of associated health outcomes, prevalence and trends of sedentary behaviour, the objective measurement of sedentary behaviour in young children, the correlates of sedentary behaviour, and finally interventions to reduce sedentary time in young children at childcare will be discussed.

2.1 Definition sedentary behaviour

Sedentary behaviour can be defined as any waking activity characterized by an energy expenditure of ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture (Tremblay et al., 2017). Sedentary behaviours are considered distinct and independent from physical activity behaviours of various intensities >1.5 METS (i.e., light- moderate- and vigorous intensity) (Salmon, Tremblay, Marshall, & Hume, 2011). This means that an individual can be physically active (i.e., meet the physical activity guidelines) but still spend prolonged periods of their day sedentary (Craft et al., 2012). In young children it has been shown that the energy expenditure of sitting is different to standing (10.3 kcal/min vs. 15.9kcal/min) (Grossek et al., 2016). The most common sedentary behaviour among young children is screen time (computer time, time watching DVD's, TV time) (LeBlanc et al., 2012). However, there are other types of sedentary behaviours that young children engage in, such as sitting and doing art and craft activities, looking at books, eating meals or passive transportation. The total time spent in sedentary behaviour (screen and non-screen time) has been shown to track moderately from early childhood into childhood (Jones, Hinkley, Okely, & Salmon, 2013).

2.2 Sedentary behaviour and health in adults

In adulthood, there is considerable evidence that spending an excessive amount of time sedentary, independent of the amount of moderate- to vigorous-intensity physical activity (MVPA) undertaken, is adversely associated with health outcomes, such as unhealthy levels of adiposity, cardiovascular disease, abnormal glucose metabolism, the metabolic syndrome, musculoskeletal disorders, and cognitive and brain health (Daneshmandi, Choobineh, Ghaem, & Karimi, 2017; de Rezende, Lopes, Rey-López, Matsudo, & do Carmo Luiz, 2014; Hamilton, Healy, Dunstan, Zderic, & Owen, 2008; Owen, Healy, Matthews, & Dunstan, 2010; Tremblay, Colley, Saunders, Healy, & Owen, 2010; Voss, Carr, Clark, & Weng, 2014). According to Hamilton et al. (2008) the negative health associations from prolonged periods of sitting are due to a lack of muscle contraction resulting in suppression of lipoprotein lipase activity (LPL) and muscle energy metabolism. Low LPL has been associated with reduced triglycerides levels, plasma high-density lipoprotein (HDL) cholesterol levels and insulin resistance (Hamilton et al., 2008). A recent review by Carter, Hartman, Holder, Thijssen, & Hopkins (2017) reported that the detrimental effects of sitting on cardiovascular health may partly be due to metabolic dysfunction following impairments in vascular health. In addition, prolonged sedentary behaviour has been shown to be negatively associated with memory, executive function and global cognition (Falck, Davis, & Liu-Ambrose, 2017). Evidence suggests this might be due to glucose and lipid metabolism impairment (Tremblay et al., 2010).

To counteract these negative health associations, numerous studies have examined the health benefits of breaking-up prolonged sedentary time with standing or walking

(Dunstan et al., 2012; Healy, Winkler, Owen, Anuradha, & Dunstan, 2015; Mullane, Buman, Zeigler, Crespo, & Gaesser, 2017; Peddie et al., 2013). Improvement in working memory and attention were reported as a result of short and frequent breaks over a 6 hour period (Mullane et al., 2017). Healy and colleagues (2015) reported that more breaks in sedentary time were beneficially associated with indicators of body composition and metabolic health. Two other studies showed improvements in glucose and insulin levels after breaking up sitting time in healthy and overweight/obese adults (Dunstan et al., 2012; Peddie et al., 2013). Peddie et al. (2013) reported improvements of glucose and insulin levels from regular breaking up prolonged sitting with short (1 min, 40 s) bouts of activity compared to continuous physical activity. These laboratory studies indicate the importance of breaking up sitting time with light physical activity (LPA), such as standing or walking to promote health in adults.

2.2.1 Sedentary behaviour and health in school-aged children and adolescents

In children and adolescents, the relationship between total sedentary time (measured objectively using wearable activity monitoring) and health outcomes is less consistent (Cliff et al., 2016), than in adults. Some studies suggest that, independent of the amount of MVPA undertaken, prolonged sedentary behaviour may be negatively associated with health outcomes in children such as adiposity, insulin resistance, academic performance and cognitive development (Cliff et al., 2014; Cliff et al., 2013; Mitchell, Pate, Beets, & Nader, 2012; Saunders et al., 2013b; Tremblay et al., 2011). According to some evidence these health associations are stronger for children who are overweight or obese (Cliff et al., 2014; Mitchell, Pate, Beets, & Nader, 2013; Saunders et al., 2013b), which includes 41 million children globally under the age of

5 years (WHO, 2016). However, after adjusting for time spent in MVPA, limited evidence indicates that sedentary behaviour is independently associated with health in children (Cliff et al., 2016).

According to a systematic review by Cliff and colleagues (2016) there have been few studies that have reported on cross-sectional associations between breaks in sedentary time and health outcomes in children, such as cardio-metabolic health and adiposity. Five out of the six cross-sectional studies in this review showed that the number of sedentary breaks was not significantly associated with adiposity outcomes (Carson & Janssen, 2011; Carson, Stone & Faulkner, 2013; Colley et al., 2013; Kwon, Burns, Levy, & Janz, 2013; Oliver et al., 2013; Saunders et al., 2013b). Two out of three studies found no associations between breaks in sedentary time and cardio-metabolic health (Carson & Janssen, 2011; Colley et al., 2013). The only study that reported a significant association was Saunders et al. (2013b), which found that more breaks in sedentary time and shorter bouts of sedentary behaviour (1-4 minutes) were cross-sectionally associated with reduced cardio-metabolic risk and lower BMI z-scores in 522 children aged 8 - 11 years, who had at least one biological parent with obesity.

A randomized cross-over study showed that a prolonged bout of uninterrupted sitting did not acutely result in adverse changes to cardio-metabolic disease risk factors in healthy children and youth compared to healthy and overweight/obese adults (Saunders et al., 2013a). In contrast, a more recent randomized cross-over study among adolescents found that breaking up sitting time had a positive acute effect on ApolipoproteinA1/ApolipoproteinB levels and a moderate effect on total cholesterol relative to prolonged sitting (Penning et al., 2017). However, Penning et al. (2017) did not see changes in glucose and insulin levels as a results of breaking up prolonged sitting. This is somewhat in contrast to the outcomes of studies in adults, which indicate that uninterrupted sitting resulted in acute and detrimental changes in insulin sensitivity and glucose tolerance relative to sitting that was interrupted with breaks (Dunstan et al., 2012). However, Dunstan and colleagues (2012) monitored glucose and insulin levels hourly, whereas Penning and colleagues (2017) measured this at pre- and post-tests, and these methodological differences are likely to have contributed to the differences in results. These studies may suggest that the acute impact of breaks in sitting on health outcomes are smaller or less apparent in children and adolescents compared to adults, however more experimental studies with randomized cross-over designs are needed in children to confirm these findings.

2.2.2 Sedentary behaviour and health in young children

In young children, limited evidence exists on the associations between sedentary time and health outcomes. Most studies have examined relationships with health using screen-based behaviours (computer time, time watching DVD's, TV time) as a proxy for sedentary behaviour (LeBlanc et al., 2012; Poitras et al., 2017). According to the most recent systematic review by Poitras and colleagues (2017), screen time behaviours have been shown to be associated with increased adiposity levels (Flores & Lin, 2013), delayed cognitive development (Carson et al., 2015b), and musculoskeletal health (Janz et al., 2001; Wosje et al., 2009). But, the association between adverse health indicators and screen-based behaviours might be due to other factors, such as increased snacking and exposure to food marketing for unhealthy foods, which is associated with TV viewing (Hobbs, Pearson, Foster, & Biddle, 2014).

2.2.2.1 Total sedentary time and Adiposity

As screen time is not the only type of sedentary behaviour young children engage in, Poitras and colleagues (2017) provided a systematic review on the associations between different types of sedentary behaviours (e.g. sitting in car seats, using books, quiet play) and health indicators (adiposity, motor development, psychosocial health and cognitive development) across different study designs. In this systematic review, eleven cross-sectional studies were included that used objective measures of total sedentary time to examine associations with adiposity in young children (Poitras et al., 2017). While in 10 of the 11 studies no relationships were found, one cross-sectional study of 357 pre-school children reported that sedentary behaviour was negatively associated with waist circumference percentile in girls (España-Romero, Mitchell, Dowda, O'Neill, & Pate, 2013). As such, this suggests that objectively measured sedentary behaviour (i.e., sitting time) may not be related to adiposity in children.

2.2.2.2 Sedentary bouts and breaks

Short bouts of sedentary behaviour and frequent breaks in sedentary time have been shown to have a positive effect on health in adults (Dunstan et al., 2012; Healy et al., 2015; Mullane et al., 2017; Peddie et al., 2013), whereas evidence is limited in young children (Poitras et al., 2017). In Poitras et al.'s review on the health consequences of sedentary behaviour in young children, only one study was identified that examined associations between sedentary bouts and health outcomes (Johansson et al., 2017). Johansson and colleagues (2017) examined the cross-sectional relationships between sedentary bouts (30 min) and indicators of adiposity and motor development in 123 young children aged two years. All participating two-year olds (n = 123) had at least one sedentary bout of 30 minutes or more, nevertheless no association was found. Another study, which was not included in the systematic review of Poitras et al. (2017), investigated the cross-sectional association between sedentary bouts and adiposity in toddlers and pre-schoolers (Kuzik & Carson, 2016) This study found an association between sedentary bouts lasting 1-4 min and BMI z-scores when adjusted for total wear time. However, after adjusting for wear time, age, sex, and parental education, the association was no longer statistically significant.

2.2.2.3 Cardiometabolic health, social cognitive development and bone and skeletal health

In the systematic review of Poitras et al. (2017), no studies were identified that investigated associations between total objective sedentary time, or bouts or breaks in sedentary behaviour and cardio-metabolic heath. Only one cross-sectional study examined the association between objectively-measured total sedentary time and cognitive development among 215 Canadian pre-schoolers. Irwin et al. (2015) reported no associations between different domains of temperament and sedentary time in pre-schoolers. Another health indicator examined in a cross-sectional study was bone and skeletal health (Hermann et al., 2015). This study reported that objectively measured sedentary time was negatively associated with bone stiffness in pre-schoolers (n = 1512). However, once analyses adjusted for MVPA, the relationship was no longer statistically significant.

It can be concluded that the total number of studies investigating associations between objectively-measured sedentary behaviour (volume and patterns) and health outcomes in young children is limited, and that the findings are inconsistent. There are only a small number of studies investigating associations between objectively-measured sedentary time and indicators of adiposity, motor development, cognitive development and there were no known studies that assessed associations for cardio-metabolic health. Further, only cross-sectional designs have been used to examine associations between sedentary time and health outcomes, which are limited for establishing causality. Furthermore, most of these cross-sectional studies used hip-based accelerometry and cut-point data analysis approaches to measure sedentary time, which have difficulties in distinguishing between different postures such as sitting, standing and stepping (De Decker et al., 2013)(see section 2.5.2.2). These postures have been found to be metabolically different in studies of adults (Winkler et al., 2017). More accurate measures, such as the thigh-mounted activPAL, which can distinguish between different postures, should be used in future studies to measure sitting time in young children. Consequently, studies using more robust designs (e.g., longitudinal and experimental designs) and more accurate measures of sedentary behaviour are needed to investigate potential associations of total sedentary time and patterns of sedentary behaviour, such as breaks and bouts, with health indicators in young children.

2.3 Guidelines for sedentary behaviour in young children

Considering the evidence showing associated health risks of excessive and prolonged sedentary time in adults (Healy, Matthews, Dunstan, Winkler, & Owen, 2011), and the potential for excessive behaviour to be harmful for health and development in children, government authorities and professional organisations have acknowledged the importance of limiting prolonged sitting and sedentary screen time in young children. Recently released Australian 24-hour movement guidelines for the early years state that for sedentary behaviour, toddlers and pre-schoolers should not be restrained for more than 1 hour at a time (e.g., in a stroller, car seat or high chair) or sit for extended periods (Okely et al., 2017). For those younger than two years, sedentary screen time is not recommended. For those older than two, sedentary screen time should be no more than one hour; less is better. When sedentary, engaging in pursuits such as reading, singing, puzzles and storytelling with a caregiver is encouraged (Okely et al., 2017).

The Institute of Medicine (IOM) have specifically developed sedentary behaviour recommendations for young children at childcare (Institute of Medicine, 2011). They state that the amount of time toddlers and pre-schoolers spend sitting or standing still should be limited to less than 30 minutes at one time. Standing still has been included in this recommendation, although it is technically not a sedentary behaviour.

2.4 Sedentary behaviour levels and patterns in young children

The aforementioned movement guidelines do not specify the proportion of total sedentary behaviour young children should accumulate across the day. Because of this, only studies describing the levels of total sedentary behaviour or sitting time will be reviewed. The levels of total sedentary behaviour in young children have been reported in a number of studies. As previously mentioned, most sedentary behaviour research has focused on screen time (TV/DVDs viewing, computer) (LeBlanc et al., 2012) and fewer studies have examined total sedentary time or sitting time. This has largely been due to the existence of guidelines focused on television and other screen-based sedentary behaviours (Canadian Society for Exercise Physiology, 2012;

Department of Health, 2011; Department of Health and Aging, 2010). Prevalence data from the Australian Health Survey 2011-12 (Statistics, 2013) indicated that only 26% of 2 to 4 years olds met the screen-based activity recommendation on all 7 days. However, television viewing comprises only one-quarter of children's total sedentary time, which leaves the rest of the sedentary time unaccounted (Baxter, 2007). Besides reporting on the prevalence of sedentary behaviour as in screen-time (Downing, Hnatiuk, & Hesketh, 2015; Rey-López, Vicente-Rodríguez, Biosca, & Moreno, 2008), one other systematic review included studies with objectively measured sedentary behaviour from children aged 2 to 5 years old (Hnatiuk, Salmon, Hinkley, Okely, & Trost, 2014). According to Hnatiuk and colleagues (2014) children aged 2 to 5 years from 10 different countries spent between 34% up to 94% of their waking day in objectively measured sedentary time. Besides the possible differences between countries and samples, such large variability in prevalence may be due to the use of different methodologies (direct observation and accelerometry). For example, 29 studies used the hip-mounted ActiGraph as a way to measure total sedentary behaviour in young children, but with different cut-points. Using different cut-points is likely to give discrepancies in estimates of time spent in sedentary behaviour (Beets, Bornstein, Dowda, & Pate, 2011). Four other studies used direct observation to assess sedentary behaviour; however, two different measurement tools were used. Therefore, consistency between studies is required to more accurately determine the prevalence of sedentary behaviour in young children.

2.4.1 Sedentary behaviour levels and patterns in young children during childcare hours

A large proportion (80%) of 3-4 year olds and around one-third of 1-2 year-olds spend some time in childcare each week (OECD - Organization for Economic Cooperation and Development, 2014). A recent systematic review implied that the childcare setting has a strong potential to shape health-related behaviours in young children (Sisson, Krampe, Anundson, & Castle, 2016). One of the earlier studies assessed sitting time in children under the age of 5 at childcare was by Brown et al. (2009). Brown et al. (2009) assessed sitting time in 476 pre-school children from 24 pre-school services, using direct observation. They showed that approximately 56% of the day was spent sitting.

More recent studies have assessed sedentary time objectively in young children at childcare using accelerometers. Twenty-three studies from different countries have objectively examined the prevalence of sedentary time in young children (aged 1 to 5.99 years) while they attend childcare; these are summarised in Table 2.1 (page 47) (Alhassan et al., 2012; Alhassan, Nwaokelemeh, Lyden, Goldsby, & Mendoza, 2013; Andersen et al., 2017; Annesi, Smith, & Tennant, 2013; Berglind & Tynelius, 2018; Byun, Liu, & Pate, 2013b; Carson et al., 2015b; Carson, Salmon, Crawford, Hinkley, & Hesketh, 2016; Delaney, Monsivais, & Johnson, 2014; Erinosho, Hales, Vaughn, Mazzucca, & Ward, 2016; LaRowe et al., 2016; Møller et al., 2017; Raustorp et al., 2012; Schlechter, Rosenkranz, Fees, & Dzewaltowski, 2017; Shen et al., 2012; Sugiyama, Okely, Masters, & Moore, 2012; Tandon, Saelens, & Copeland, 2017; Tucker, Vanderloo, Burke, Irwin, & Johnson, 2015; Van Cauwenberghe, De Bourdeaudhuij, Maes, & Cardon, 2012; Vanderloo et al., 2014; Ward et al., 2017).

Scientific peer reviewed published papers using any study design were considered. First, studies were eligible if sedentary behaviour was objectively measured with an activity monitor (eg. Actigraph, activPAL, Actiheart, Actical

, or other), and secondly the sample included healthy young children who could walk independently and who did not attend formal primary/elementary school. According to these 23 studies, the percentage of time spent in sedentary behaviour during childcare hours ranged from 40% up to 89%, with an average of 65%. This indicates that approximately two-thirds of young children's time at childcare is spent in sedentary behaviour, which is a large proportion of their day. Therefore, childcare settings may provide an ideal setting to intervene to reduce total sitting time or to break up prolonged sedentary time in young children and support the development of healthy habits. However, similar to the proportion of sedentary behaviour levels in the previous section, there is still large variability across these 23 studies. Similar to the review by Hnatiuk et al. (2014), the use of different methodologies might be the explanation. Fourteen studies used the ActiGraph, eight studies used the Actical and only one study used the activPAL. This highlights again that there needs to be consistency in measurement approaches between studies to accurately determine the prevalence of sitting time in childcare.

2.4.1.1 Sedentary behaviour in young children within Australian childcare centres

In Australia, only three studies have objectively measured sedentary behaviour in young children within Australian childcare settings (Carson et al., 2016; Sugiyama et al., 2012). First, Sugiyama et al. (2012) reported that on average, the pre-schoolers (3-5 years) in their sample (n = 89) from 10 childcare centres in Brisbane spent 81% of their time at child care sedentary. Second, Carson and colleagues (2016) found that pre-schoolers (n=177) from Melbourne spent 48% of their time sedentary while at childcare. Third, Ellis and colleagues (2016) (this paper is reported in detail in Chapter 3 of this thesis) found that young children (n=301) from 11 childcare centres across the Illawarra spent on average 48% of their day sitting. Besides the sample size differences, the variance between prevalence rates might be explained due to methodological differences. The first two studies used the ActiGraph (Sugiyama et al., 2012), however different cut-points may explain the large differences in sedentary time. The third study used the activPAL to measure sitting time (Ellis et al., 2016). Nevertheless, the first two studies (Carson et al., 2016; Sugiyama et al., 2012) that examined total sedentary behaviour in childcare did not report on compliance with the current Institute of Medicine (IOM) recommendation for sedentary behaviour and physical activity in young children at childcare As such, there is a lack of prevalence data relating to compliance with the IOM recommendations within Australian childcare centres. It is unknown how much sedentary behaviour is considered excessive. Using the IOM recommendations, compliance rates can be reported. Because of the small number of studies and potential measurement issues, more evidence is needed on the prevalence of sedentary behaviour in young children within Australian childcare centres using accurate objective measures.

2.4.1.2. Sedentary behaviour patterns

Little is known about how young children accumulate sedentary behaviour (breaks and bouts) during their day at childcare. Only three studies have reported on sedentary bouts or breaks in young children at childcare (Berglind & Tynelius, 2018; Carson et al., 2016; Kuzik, Clark, Ogden, Harber, & Carson, 2015). Baseline data from an

Australian longitudinal study in 177 children aged 3 to 5 years showed that the majority of their time at childcare was spent in 1-4 minutes sedentary bouts (Carson et al., 2016). Likewise, a Canadian study in 114 children aged 19-60 months showed that sedentary behaviour was primarily accumulated in 1-4 minute bouts (Kuzik et al., 2015). It was also shown that pre-school aged children had significantly less sedentary bouts per hour lasting 10 - 14 mins and >15 mins. Another cross-sectional study by Andersen et al. (2017) reported data from 111 children, aged 3 or 4 years old. They showed that the least active groups had a greater number of sedentary bouts during the day compared to the most active group. However, in all three studies, accelerometers worn on the waist (Actical or ActiGraph) were used to measure sedentary bouts, which are unable to accurately capture postures. This limitation may cause misclassification of sedentary bouts, thus future studies should use devices such as inclinometers to minimize measurement error (Ridgers et al., 2012).

Table 2.1 Prevalence of sedentary behaviour while attending childcare among young children

Study (Year), country	Sample (total number, (%boys), mean age ± SD)	Measure	Sedentary time (%; mean ± SD)
Alhassan et al. (2012), USA	43 (51%) 4.3 ± 0.6y	ActiGraph GT1M	78.3% ± 4.5
Raustorp et al. (2012), Sweden & USA	50 (52%) 4.4 ± 0.6 y	ActiGraph GTM1	USA: indoors= 89.1%; outdoors = 75.2% Sweden: Indoors = 87.4%; outdoors 76.3%
Cauwenberghe et al. (2012), Belgium	128 (54%) 4.6 ± 0.7 y	ActiGraph GT1M	65.3% ± 14.7
Sugiyama et al. (2012), Australia	89 (54%) 4.1 ± 0.6 y	ActiGraph GT1M	81.2% ± 17.2
Alhassan et al. (2013), USA	38 (59%) 4.1 ± 0.8 y	ActiGraph GT1M	77.4% ± 5.2
Byun et al. (2013), USA	155 (51%) (4.0 ± 0.7 y)	ActiGraph 7164	63.3% ± 7.5
Annesi et al. (2013), USA	885 (49%) (4.4 ± 0.5 y)	ActiGraph GT3X	59.1% ± 7.3
Delaney et al. (2014), USA	144 (NR) (4.0 ± 0.6 y)	ActiGraph GTM1	57.2% ± 7.7
Vanderloo et al. (2014), Canada	31 4.10 ± 0.85	Actical	68% ± NR
Carson et al. (2015), Canada	Toddlers 36 (50%) Pre-schoolers 50 (50%) (3.3 ± 0.2 y)	Actical	63.1% ± 6.6 58.7% ± 12.7
Kuzik et al. (2015), Canada	114 (81%) 38 months ± 12.4	Actical	61.5% ±NR
Tucker et al. (2015), Canada	218 (46.8%) 4.18 ± 0.97 y	Actical	69.4% ± NR
Carson et al. (2016), Australia	177 (57%) (4.2 y ± NR)	ActiGraph GT1M	47.8% ± 12.0
Tucker et al. (2016), Canada	216 (47%) (4.2 ± 1.0 y)	Actical	67.3% ± 6.6
LaRowe et al. (2016), USA	231 (NR) 2 – 5 y	Actical	60.5% ± 11.6
Erinosho et al. (2016), USA	544 (50%) 3-5 y	ActiGraph GT1M	63.4% ± 3.7
Tandon et al. (2017), USA	388 (49%) (4.3 ± 0.7 y)	Actical	60.0% ± NR
Schlechter et al. (2017), USA	73 (47%) (4.4 ± 0.9 y)	ActiGraph GT1M	69.5% ± 12.4
Ellis et al. (2017), Australia	301 (48%) Toddlers: 71 Pre-schoolers: 230 3.7 ± 1.0 y	ActivPAL	40.3% ± 11.8 50.6% ± 21.2
Andersen et al. (2017), Norway	130 (43%) (3.7 ± 0.4 y)	ActiGraph GT1M and GT3X+	54.0% ± NR
Ward et al. (2017), Canada	624 (52%) (4.0 ± 0.7 y)	Actical	63.9% ± 12.3
Møller et al. (2017), Denmark	231 (51%) (3.0 ± 0.1 y)	ActiGraph GT3X	47.9% ± 7.9 51.2% ± 9.3
Berglind et al. (2017), Sweden	899 (84%) 4y	Actigraph GT3X+	39% ± NR

2.5 Measurement of sedentary behaviour in young children

The evidence in previous paragraphs (2.2 and 2.4) shows there is inconsistency in results across studies of sedentary behaviour in young children. Firstly, studies examining sedentary behaviour and the relationship with health outcomes in young children report contrasting findings. Secondly, there is considerable variation between studies in the reported amount of time that young children engage in sedentary behaviour. Some of the inconsistency in study findings may be due to differences in the measurement of sedentary behaviour. It is therefore critical to accurately measure young children's sedentary behaviour.

The accurate measurement of sedentary behaviour in young children requires researchers to measure the posture of sitting (Janssen & Cliff, 2015). Therefore, this section will describe different methods to measure sedentary behaviour in young children. First, subjective measures (questionnaires, self reports e.g.) of sedentary behaviour will be discussed. Then the use of objective measures will be explored, starting with direct observation followed by the use of accelerometry to examine sedentary behaviour in young children.

2.5.1 Subjective measures of sedentary behaviour

Historically, subjective measures, such as self- or parent-report, questionnaires, diaries or interviews have been used to assess the time young children spend in sedentary screen time (Dennison, Erb, & Jenkins, 2002; Hardy, King, Hector, & Lloyd, 2012; Jago, Baranowski, Baranowski, Thompson, & Greaves, 2005; Jouret et al., 2007; Trost, Sirard, Dowda, Pfeiffer, & Pate, 2003; Vandewater, Shim, & Caplovitz, 2004). Self-report measures have several strengths. They are easy to administer, relatively inexpensive, and have the ability to record the context in which sedentary behaviour occurs (Hidding, Altenburg, Mokkink, Terwee, & Chinapaw, 2017; Trost, 2007). However, these subjective measures may not provide accurate estimates of the amount of total sedentary behaviour, as they are prone to recall bias, especially underreporting (Timmons et al., 2012; Trost, 2007). In addition, children younger than 10 years cannot remember activities accurately and are unable to count the amount of time spent in an activity (Baranowski, 1988). Furthermore, as screen time is only one type of sedentary behaviour, measures that only assess sedentary screen time are inappropriate for estimating children's total sedentary time.

2.5.2 Objective measures of sedentary behaviour

2.5.2.1 Direct observation

Direct observation is another technique used to provide a more objective, valid and reliable assessment of sedentary behaviour in children compared to subjective measures (Trost, 2007). Observers typically observe sedentary behaviour either live or on video and code behaviours into categories. However, direct observation systems in natural settings such as childcare centres typically use momentary time sampling to get representative estimates across groups of children. Consequently, group-level behaviours are normally assessed rather than individual behaviours. Such an approach can be used to capture individual-level habitual behaviour (i.e., daily behaviour that occurs across settings such as in the home and at childcare), but it is highly labour intensive and expensive (Trost, 2007). Hence, objective measures, such as wearable activity monitors have become the most common measures of total sedentary behaviour.

2.5.2.2 Accelerometry

Accelerometers are currently the most common method for measuring total sedentary behaviour in pre-school children (Cliff, Okely, Smith, & Mckeen, 2009; Pate, McIver, Dowda, Brown, & Addy, 2008). As the name suggest, accelerometers measure the acceleration of the body when examining sedentary behaviour and physical activity. The advantage of using accelerometers is their ability to provide a daily profile of sedentary, light, moderate and vigorous movement over longer periods of time, such as an entire week (Colley et al., 2013) compared to methods such as direct observation (Brown et al., 2009; Pate, O'neill, & Mitchell, 2010). They are furthermore small and light, and robust, which makes them feasible to use in large-scale studies.

2.5.2.3 ActiGraph and Actical

The most widely used accelerometers among pre-school children are the ActiGraph (Actigraph corporation; Pensacola USA) and Actical (Philips Respironics, Bend ,OR). A limitation with this methodology with respect to measuring sitting time is that devices have typically been placed on the waist at the hip. Furthermore, data has traditionally been reduced using cut-point-based thresholds to distinguish sedentary behaviour (i.e., low acceleration) from physical activity (i.e., higher acceleration). The combination of hip-placement and cut-point based data reduction results in difficulties in accelerometers distinguishing between postures such as sitting and standing still (Chen, Janz, Zhu, & Brychta, 2012). This is important, as the definition of sedentary behaviour only includes activities undertaken in a sitting/lying position (Tremblay et al., 2017). These postures have been found to be metabolically different in studies in adults (Healy et al., 2015). Because of difficulties in differentiating between sitting and standing, hip-mounted accelerometers also have difficulties in accurately assessing the number of breaks in sedentary behaviour.

2.5.2.4 ActivPAL

Newer devices that have been designed to be worn on the thigh, such as the activPAL4 TM (PAL Technology Ltd., Glasgow, UK), appear to be more sensitive to changes in sitting posture, and therefore more accurate for assessing sedentary behaviour compared to hip-mounted accelerometers combined with traditional cut-point approaches (Van Loo et al., 2017). The activPAL has been evaluated and validated for detecting postural transitions in pre-school children (Davies et al., 2012; Davies, Reilly and Paton, 2012; De Decker et al., 2013; Janssen et al. 2014). Details of these studies are described in Table 2.2 Three studies have examined the validity of the activPAL for assessing total sedentary behaviour (Davies et al., 2012a; De Decker et al., 2013; Janssen et al., 2014). Two studies reported that the activPAL has acceptable validity, practical utility, and reliability for the measurement of posture, including sedentary behaviour, in pre-school children (Davies et al., 2012a; Janssen et al., 2014). This is in contrast with the findings from De Decker et al. (2013) who reported poor classification accuracy for assessing sedentary behaviour and non-sedentary behaviour.

Two studies have examined the validity of the activPAL for assessing breaks in young children. The activPAL appeared to be inaccurate when predicting total number of breaks compared to direct observation (Davies, Reilly, & Paton, 2012b; Janssen et al., 2014). Davies et al. (2012) included thirty children with a mean age of 4.1 years who were videoed for 1 hr in nursery while wearing an activPAL. The estimates from the activPAL were compared against direct observation from the video. The authors reported that the activPAL was relatively accurate in ranking children from highest to lowest for the number of breaks accumulated, but when compared to the direct observation results the total number was over-estimated. Janssen et al. (2014) validated the activPAL among forty healthy 4- to 6-year-old children in a laboratory setting. The activPAL performed well when classifying postures of sitting, standing and stepping in young children. However, the activPAL overestimated time spent sitting and standing and underestimated walking compared to direct observation. Also in this study the number of breaks was overestimated (Janssen et al., 2014).

It appears that the activPAL may potentially have some inaccuracies for assessing breaks in sedentary behaviour in young children. However, more recently it was shown that the activPAL is more accurate for assessing sedentary behaviour compared to available cut-point based approaches for the hip- and wrist-mounted ActiGraph and GENEActiv. It is furthermore the only monitor that can distinguish between different postures (i.e., sitting, standing and stepping). Therefore, the activPAL is currently the most appropriate method to assess sedentary behaviour (sitting time) and sedentary breaks in young children.

Table 2.2 Validation studies for the activPAL in young children.

Author	Sample	Method	Criterion Measure	Activities	Validity
Davies et al. (2012)	n = 30 Age = 3-4 years Mean age = 4.1 years 10 girls, 20 boys	activPAL	Direct observation	60 minutes of usual nursery activities	Sit/lie: Se = 92.8%; Sp = 97.3% Stand: Se = 91.8%; Sp = 86.5% Walk: Se = 77.9%; Sp = 96.5%
Davies et al. (2012)	n = 30 Age = 3-4 years Mean age = 4.1 years 10 girls, 20 boys	activPAL	Direct observation	60 minutes of usual nursery activities	Posture transitions: Wilcoxon paired test showed significant difference. Spearman r = 0.79
De Decker et al. (2013)	n = 44 Age = 4-6 years Mean age = 5.5 years 10 girls, 20 boys	activPAL	Direct observation	60 minutes of classroom activities at pre-school	Sitting: ROC-AUC = 0.61; Se = 53.8%; Sp = 67.5% Sitting and Standing: ROC-AUC = 0.52; Se=27.8%; Sp = 75.8%
Jansen et al. (2014)	n = 40 Age = 4-6 years Mean age = 5.3 years 18 girls, 20 boys	activPAL	Direct observation	150 minute structured activity protocol in the laboratory	Sit/lie ROC-AUC = 0.88; Se = 87.6%; Sp = 88.1% Standing: ROC-AUC = 0.77; Se = 52.5%; Sp = 77.9%; Walk: ROC-AUC = 0.74; Se = 52.5%; Sp = 52.5%

Se, Sensitivity; Sp, specificity; ROC-AUC, area under the receiver operating characteristic curve

2.6 Correlates of sedentary behaviour in young children

Understanding the correlates of sedentary behaviour in young children will help inform interventions to reduce prolonged sitting and prolonged time spent restrained. This section reviews the correlates associated with sedentary behaviour in young children.

2.6.1 Social ecological framework

Sedentary behaviour is complex and influenced by multidimensional factors that work at a range of ecological levels. These ecological levels are described in the Social Ecological Framework (Sallis et al., 2000), which is helpful for understanding the dynamics of relations between personal and environmental factors (Kearns, 2010). This framework can include, but is not limited to, demographic and biological characteristics, psychosocial, cognitive and emotional traits, behavioural characteristics, social and cultural variables and environmental factors (Sallis et al., 2000).

2.6.2 Correlates of objectively measured sedentary behaviour in young children

To the author's knowledge, 13 studies have specifically investigated correlates of objectively measured total sedentary behaviour in young children (Table 2.3) (Berglind, Hansson, Tynelius, & Rasmussen, 2017; Berglind & Tynelius, 2018; Byun, Dowda, & Pate, 2011; Carson & Kuzik, 2017; Cerin et al., 2016; Dolinsky, Brouwer, Østbye, Evenson, & Siega-Riz, 2011; Downing, Hinkley, Salmon, Hnatiuk, & Hesketh, 2017; Fisher et al., 2005b; Johansson et al., 2015; Matarma et al., 2017; Schmutz et al., 2017; Vanderloo & Tucker, 2015; Wijtzes et al., 2013). This section does not include studies specifically focused on childcare, which are reviewed in the subsequent section (see section 2.6.3). For the first level of the Social Ecological Framework (Individual level), eleven studies objectively measured the association between sedentary time and a child's sex. Six of these studies (55%) found an association, with girls spending more time in sedentary behaviour than boys (Berglind et al., 2017; Berglind & Tynelius, 2018; Byun et al., 2011; Carson & Kuzik, 2017; Dolinsky et al., 2011; Wijtzes et al., 2013). Four out of five studies (80%) showed no association between sedentary time and age in young children (Byun et al., 2011; Carson & Kuzik, 2017; Johansson et al., 2015; Schmutz et al., 2017). Ethnicity was not associated with sedentary behaviour in pre-schoolers or toddlers in three out of three studies (Byun et al., 2011; Carson & Kuzik, 2017). Four out of five studies (80%) found that the number of siblings was not associated with sedentary time in young children (Byun et al., 2011; Carson & Kuzik, 2017; Downing et al., 2017; Matarma et al., 2017). Three out of three studies reported no association between SES and sedentary behaviour in young children (Carson & Kuzik, 2017; Schmutz et al., 2017; Vanderloo & Tucker, 2015). Parental education was measured in six studies. Five out of these six studies (81%) showed no association between parental education and sedentary behaviour (Carson & Kuzik, 2017; Downing et al., 2017; Johansson et al., 2015; Schmutz et al., 2017; Vanderloo & Tucker, 2015).

Associations between psychosocial, behavioural and physical environment correlates and sedentary behaviour have been investigated in six studies (Berglind & Tynelius, 2018; Byun et al., 2011; Cerin et al., 2016; Downing et al., 2017; Matarma et al., 2017; Schmutz et al., 2017). Two out of four studies (50%) found that outdoor time was negatively associated with sedentary behaviour in both boys and girls (Cerin et al., 2016; Schmutz et al., 2017). Furthermore, two out of three studies (67%) reported seasonal variations in objectively measured sedentary behaviour; specifically, that sedentary behaviour was higher in winter compared to other seasons in a sample of Dutch toddlers (Wijtzes et al., 2013) and Scottish pre-schoolers (Fisher et al., 2005b). One out of two studies (50%) showed that sleep duration was inversely related with sedentary behaviour (Downing et al., 2017; Schmutz et al., 2017).

Physical activity equipment in the home was negatively associated with sedentary behaviour in boys in the home environment in one out of two studies (Byun et al., 2011). Byun et al. (2011) was also the only study to investigate associations between athletic coordination and sedentary behaviour, and reported a negative association between the two among girls but not boys. Lastly, one study reported inverse associations between sedentary behaviour and activity temperament, neighbourhood safety, family situation (single parent and dual parent households) and parental sports club membership among Swiss pre-schoolers (Schmutz et al., 2017).

Overall, results on associations between sedentary behaviour and non-modifiable correlates (e.g. sex, age, ethnicity) in young children have been inconsistent. Furthermore, there are few consistencies between studies to identify modifiable correlates of sedentary behaviour in young children. More research with better designs is needed to confirm the correlates of sedentary behaviour. However, although an understanding of total sedentary behaviour is important contextual information, the development of an effective intervention to reduce sedentary behaviour in childcare will likely require an understanding of the specific correlates of children's sedentary behaviour for that setting.

Table 2.3 Correlate studies of objectively measured sedentary behaviour (SB) in young children

Author	Sample	Measure	Correlates	Outcome
Fisher et al. (2005) Scotland	n = 209 Mean age = 4.8 (1.2) y 101 boys, 108 girls	CSA WAM 7164 acceleromet er (MTI, Fort Walton Beach, FL	Season	SB significantly higher in spring compared to summer or fall
Byun et al. (2011) USA	n = 331 Mean age = 4.3 (0.6) y 168 boys, 163 girls)	ActiGraph	Sex, Age, siblings, Race, BMI z-score, Perceived enjoyment of PA, Perceived amount of PA, Perceived importance of PA, Perceived level of PA, Athletic coordination, choice of activity, participate in organized sports, outdoor play, residence type, distance to park, safety of park, usage of park, PA equipment's,	Physical activity equipment in the home was sig correlate of SB in boys. For girls, BMI z score and child's athletic coordination were significantly associated with SB.
Dolinski et al. (2011) USA	n = 337 Mean age = 2-5y 3.5 (1.1) 195 boys, 142 girls	Actical	Sex, time spent outdoors, maternal activity	Boys had significantly less sedentary time than girls
Wijtzes et al. (2013) Netherlands	n = 347 Mean age=2y 182 boys, 165 girls	ActiGraph	Sex, Age, Preterm birth, Birth weight, Infant temperament, gross motor development, BMI z-score, season	Levels of sedentary behaviour were higher among girls compared with boys and during winter season compared with spring. Levels of sedentary behaviour were lower among older children and children with 2 or more siblings compared with children without siblings
Johansson et al. (2015) Sweden	n = 123 Mean age = 2.03y 62 girls, 61 boys	ActiGraph	Sex, Age, BMI, Weight status, Family group, Neurological Optimality Score, first born, Child care, high parental education	No association
Vanderloo and Tucker (2015) Canada	n = 40 Mean age = 18-29 months 18 male, 22 female	Actical	Sex, type of learning environment, ethnicity, family situation, highest level of parent/guardian education, approximate annual household income	No associations
Berglind et al. (2016) Sweden	n = 540 Mean age = 4.2 (0.15) y 229 girls, 311 boys	ActiGraph	Sex, weight status, weekday, weekend	Boys spend significantly less time sedentary compared to girls. Boys and girls spent less time being sedentary on weekdays compared with weekends.

Cerin et al. (2016) USA	n = 84 Mean age = 4.5 (0.8)y NR	ActiGraph	Indoor, outdoor, location type	Outdoor time negatively associated with sedentary behaviour and indoor time positively associated.
Matarma et al. (2016) Finland	n = 140 Mean age = 5.6 (0.3)y 62 boys, 72 girls	ActiGraph	Sex, weight status, season, siblings, day care, organized PA, education mother, education father, MVPA mother, MVPA father	Childs sedentary time was positively associated with mother's sedentary time. Sedentary time in highly educated fathers was associated with sedentary time in children.
Berglind and Tynelius (2017) Sweden	n = 899 Mean age = 4 y NR	ActiGraph	Sex, weekday vs. weekend days, time spent outside pre-school	Boys spent significantly less time sedentary compared to girls Both boys and girls were more active and less sedentary on weekdays compared with weekend days
Carson and Kuzik (2017) Canada	n = 149 Mean age = 19.0 (1.9) months 71 girls, 78 boys	ActiGraph	Sex, age, race/ethnicity, type of childcare, number of siblings, Parental characteristics, age, sex, marital status, country of birth, highest level of education, household income	Toddlers' sex (female vs. male) was significantly positively associated with sedentary time
Downing et al. (2017) USA	n = 717 Mean age = 3-5 y 394 boys, 323 girls	ActiGraph	Sex, sleep duration, child disability, child's birth parents live together, child has siblings, weight status, maternal BMI category, maternal education, paternal BMI category, paternal education, child PA and SB, child personality, preferences and constraints, parental influence, rules and boundaries, social interaction and support, modelling of PA, physical environmental level,	Sleep duration was inversely related with girls sedentary time
Schmutz et al. (2017) Switzerland	n = 394 Mean age = 3.9 (0.7) y 53.9% boys	ActiGraph	Sex, age, birth weight, chronic health condition, BMI, Gross motor skills, siblings, parental BMI, SES, family structure, self regulation, psychological difficulties, emotionality temperament, activity temperament, shyness temperament, parenting stress, cognitive performance, sleep duration, play frequency, parental sedentary behaviour, parental sport club membership, parental physical activity, parental involvement in child pa, transport to childcare, parental tobacco use, parental alcohol consumption, time outdoors, fixed toys, portable toys days at childcare, living area per person, neighbourhood safety, dog, season, region, TPA, MVPA	Activity temperament, time outdoors, neighbourhood safety, family situation and parental sports club membership were inversely related to SB.

2.6.3 Correlates of objectively measured sedentary behaviour in pre-school children in childcare settings

A recent systematic review by Tonge et al. (2016) identified correlates of sedentary behaviour within childcare services using a Social Ecological Framework. In the following section, the review by Tonge et al. (2016) will be summarised and the evidence will be updated with studies that were not included in the review or that have been published since this review. Within this framework, four levels were reviewed: child, educator, physical environment and organisational domains.

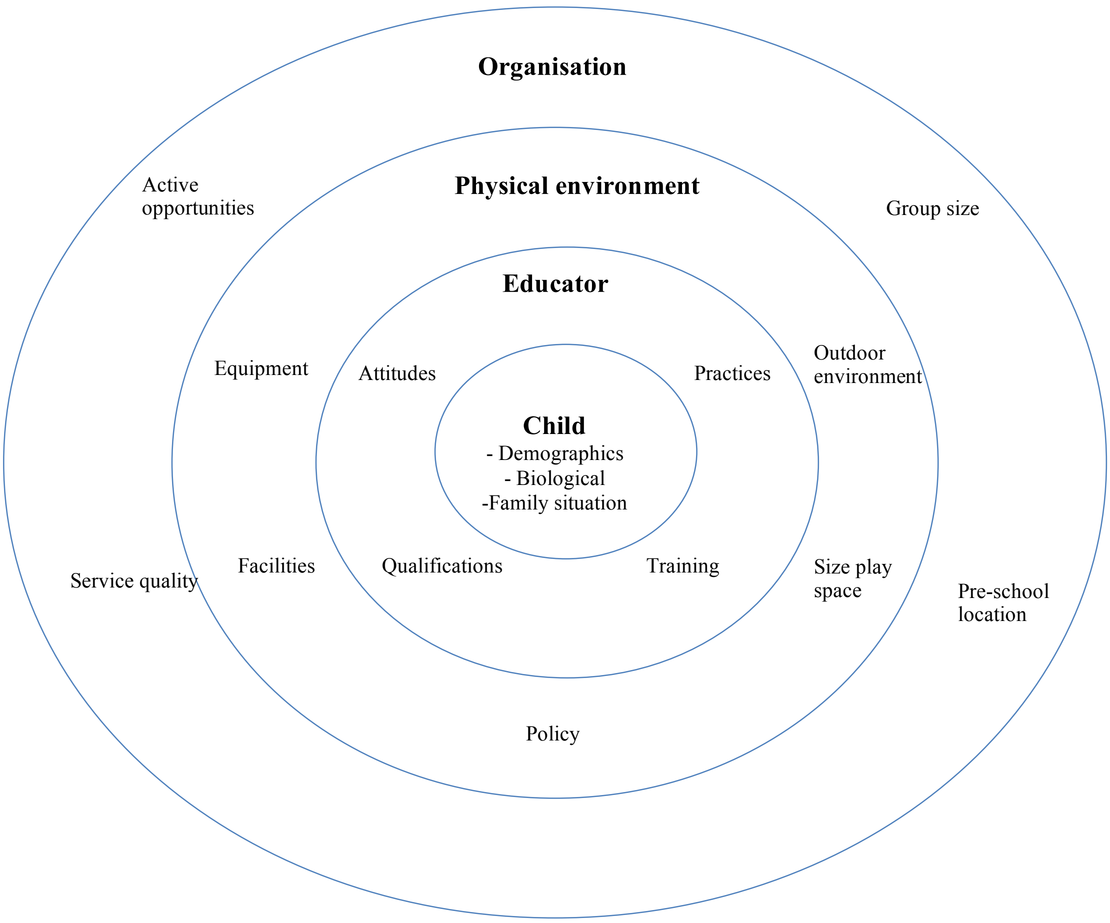

Figure 2. 1 Correlates of sedentary behaviour within Childcare grouped in different domains, based on Tonge et al.'s (2016) systematic review

2.6.3.1 Child

Child variables included demographic characteristics, such as sex, age, ethnicity and parent education. In the systematic review by Tonge et al. (2016), differences in sedentary behaviours by sex were found. Based on the findings of one study (Byun, Blair, & Pate, 2013a), Tonge et al. concluded that sex was a correlate of sedentary behaviour during childcare, with girls being more sedentary than boys. This finding is consistent with a study completed by Ellis et al. (2016) who reported that girls were more sedentary compared to boys (49% vs 47%; P=0.003) in childcare.

Another reported correlate of sedentary behaviour was age (Tonge, Jones, & Okely, 2016). One study showed that age was a predictor for sedentary time in pre-schoolers, with sedentary time being lower in older pre-schoolers (Byun et al., 2013a). This is in contrast with the results from Ellis et al. (2016), who showed that older children (pre-schoolers) were more sedentary compared to younger children (toddlers) in childcare, (see Chapter 3 for further details). Differences between the studies could be due to differences in age, as Byun and colleagues (2013a) only included 4 year olds, so no comparison was made with toddlers. Tonge et al. (2016) found that ethnicity of the children was related to sedentary behaviour, which was only based on one study. The limited number of studies on ethnicity and sedentary behaviour, highlights the need for more studies in young children at childcare to confirm these findings.

2.6.3.2 Educators

In Tonge et al's (2016) review, five studies examined associations between sedentary behaviour and educator's characteristics, including qualifications, training, and attitudes and practices in childcare. None of these characteristics showed an association with sedentary behaviour.

2.6.3.3 Physical environment

The physical environment domain in the systematic review by Tonge et al. (2016) showed that the presence of an outdoor environment and larger play space was beneficial in reducing sedentary behaviours (Tonge et al., 2016). These two correlates were reported in three out of four studies. Another recent study by Schmutz et al. (2017) shows that more time spent outdoors was associated with lower sedentary behaviour levels in pre-schoolers at childcare. In addition, weather was not considered in the review of Tonge et al. (2016), but has been shown to influence sedentary behaviour in young children at childcare. One study used objective measures in pre-schoolers and found that sedentary time during childcare in summer and autumn/fall was lower compared to spring in childcare in Glasgow (Scotland) (Fisher et al., 2005a). Consistent with conclusions from the Tonge et al. (2016) review, it appears that environmental factors show the most consistent associations with children's sedentary behaviour in childcare.

2.6.3.4 Organisation

The organisation domain includes factors such as active opportunities, service quality, pre-school location, policies and number of children who attend childcare. Based on two studies, Tonge et al. (2016) concluded that there is an association between policy and sedentary behaviour. These two studies showed that pre-school children were less sedentary in childcare centres with physical activity policies and provided more opportunities for physical activities indoors and outdoors, compared to lower quality childcare centres. These findings are consistent with a more recent study by Peden et al. (2017), showing that pre-school children who attended high-quality services sat less (-7.81 [-26.64. 11.02]) than those in low- and medium-quality services. However, the opposite was found for toddlers. Toddlers from high-quality services sat more (8.73 min [-10.26, 27.73]) than those who attended low quality services. This suggests that high-quality childcare centres with physical activity policies positively influence pre-school children sedentary time but not sedentary time in toddlers.

Taken together, this review of the correlates of sedentary behaviour in young children highlights gaps in our knowledge. Several correlates have been studied, however few of these correlates have not been investigated frequently enough to draw definite conclusions. Also, all studies, other than the one study reported in Chapter 3 of this thesis, have used hip-mounted accelerometers to measure sedentary behaviour, which is known to over-estimate sedentary behaviour (De Decker et al., 2013), and would thus impact the associations with correlates. Future studies should consider using more direct measures of sitting behaviour, such as the thigh-mounted activPAL, capable of distinguishing between different postures (sit, stand, step) to provide a more accurate assessment of sedentary behaviour compared to hip-mounted accelerometers (Janssen et al., 2014).

As there are such a small number of studies investigating correlates of sedentary behaviour in young children at childcare, and because most studies have identified correlates such as age, sex and ethnicity (which are non-modifiable), it is difficult to draw conclusions about factors to target in interventions. According to the above findings, the outdoor environment was found to be a consistent correlate of sedentary behaviour. However, only a few studies have identified modifiable correlates, including childcare policies on physical activity and sedentary behaviour. It is therefore important to expand and strengthen the knowledge about the correlates of young children's objectively measured sedentary time during childcare in order to target key influencing factors in the development of effective interventions.

2.7 Interventions

The literature in previous sections confirms that the compliance with the sedentary behaviour IOM recommendation in young children is low and that high levels of total sedentary time is adversely associated with some health outcomes. Therefore, developing, implementing and evaluating interventions to reduce total and prolonged sedentary behaviour in young children is important. This section will describe the evidence of current interventions in reducing sedentary behaviour in young children.

2.7.1 Interventions reducing sedentary behaviour

In recent years, most systematic reviews have reported on interventions increasing physical activity or preventing obesity in young children (Bluford, Sherry, & Scanlon, 2007; Campbell & Hesketh, 2007; Downing, Hnatiuk, Hinkley, Salmon, & Hesketh, 2016; Hesketh, Lakshman, & Sluijs, 2017; Skouteris et al., 2011; Ward, Vaughn, McWilliams, & Hales, 2010). These systematic reviews also include interventions that assessed sedentary behaviour, but there is only one systematic review that exclusively focused on interventions with sedentary behaviour outcomes (Downing et al., 2016). In total there were 12 interventions that aimed to reduce sedentary time in young children. These interventions were performed in the pre-school/day care, home and community-based setting. Only four interventions were effective at decreasing sedentary time, of which three had the primary aim to increase physical activity and only one intervention targeted sedentary time directly. A meta-analysis was performed in this review on seven studies that reported intervention effects on a continuous objective measure of sedentary time. The results of the meta-analyses showed a significant overall reduction in daily sedentary time of around 19 minutes between the two groups (95% CI -33.31 to -4.51). Furthermore, there were no differences depending on the duration of the intervention. Interventions that targeted physical activity alone, but reported sedentary time results, were shown to be more effective than interventions that specifically targeted decreasing sedentary time in addition to promoting physical activity. However, the subgroup analyses (child age, intervention duration, intervention setting and targeted behaviours) show the small number of interventions focusing on reducing sedentary behaviour. Therefore, the findings of the subgroup analyses should be interpreted with caution.

2.7.2 Interventions targeting reductions in sedentary time in young children at childcare

Nine of the 13 studies in the systematic review of Downing et al. (2016) that examined changes in objectively measured sedentary behaviour were conducted in pre-schools and one was conducted in childcare centres. The authors reported four studies that showed significant reductions in sedentary time. Of those, three studies were focused on increasing physical activity (Alhassan et al., 2012; Alhassan et al., 2013; De Bock, Genser, Raat, Fischer, & Renz-Polster, 2013), and only one study targeted sedentary time directly in childcare (De Craemer et al., 2016). De Craemer and colleagues (2016) evaluated the effects of the ToyBox- intervention (a European 24-week cluster randomized controlled trial) using the ActiGraph in 859 Belgian pre-schoolers from 27 kindergartens (15 intervention and 12 control). This study involved environmental changes in the classroom, movement breaks, stories and activities for children, newsletters for parents and a poster with key messages to decrease sedentary behaviour was handed out by educators to the pre-schoolers to take home. No intervention effect on objectively measured sedentary time during childcare hours was found overall, but sub-group analyses did find a decrease in sedentary time during childcare hours for pre-schoolers from high socioeconomic kindergartens. However, given this is the only study directly focusing on reducing sedentary time in pre-school aged children at childcare, it highlights the need for more interventions in this setting and with other demographic groups.

In summary, the majority of interventions that were successful in reducing sedentary behaviour in young children at childcare focused primarily on increasing physical activity. However, sedentary behaviours have been shown to have separate correlates to physical activity, therefore to target sedentary behaviour, specific interventions should be implemented. More interventions should focus on finding ways to reduce sedentary time which should positively impact time spent in (light-intensity) physical activity.

2.7.3 Translation of research into policy and practice

Translating the evidence from research/interventions into policy and practice is the last and least studied phase of the epidemiological behaviour framework. Policies are defined as laws, regulations, formal rules, informal rules or understandings that are adopted on a collected basis to guide individual and collective behaviour (Schmid, Pratt, & Howze, 1995). Policy makers need to be informed by evidence from previous phases of the behavioural epidemiology framework. Recent evidence has caused an increased awareness of the importance of the early childhood period in many local and state organizations, which are encouraged to examine regulations in childcare settings. Policy recommendations or standards focused on sedentary behaviour have been developed (Institute of Medicine, 2011; Society for Behavioural Medicine 2015; Okely, Tremblay, Hammersley, & Aubert, 2018), which is an important step to preventing high and unhealthy levels of total sedentary behaviour. Engaging childcare organisations is important as they can translate this knowledge, determine if guidelines are relevant to the childcare organisation and children, and identify strategies for effectively communicating the guidelines.

Only one study has examined the impact of revising sedentary behaviour guidelines in 86 toddlers and pre-schoolers while in childcare settings in Alberta, Canada (Carson, Clark, Ogden, Harber, & Kuzik, 2015a). The participating childcare centres received a letter with the revised standards and highlighted the new standard around physical wellness. They received varying support with their Quality Enhancement Plans from coaches through the Alberta Resource Centre for Quality Enhancement. These coaches helped centres set goals around sedentary behaviour in the quality enhancement plan, such as scheduling breaks in sedentary time. The results of this pre-post design study showed that over a 6.5 months period, toddlers decreased sedentary time of 3.1min/h across eight childcare centres, increased MVPA and decreased BMI z-score. Among pre-schoolers there was a small increase (1.9 min/h) in sedentary time and small decrease in LPA. Carson et al. (2015) explained that this might be due to the fact that pre-schoolers are preparing to attend school, which may involve longer periods of sedentary tasks (academic activities). This study highlights the potential power of a government led policy on decreasing sedentary behaviour and BMI z-score in toddlers. Furthermore, few studies have evaluated outcomes related to the Institute of Medicine sedentary behaviour guidelines in childcare (Ellis et al., 2016; Pate et al., 2015), while other groups have examined isolated components of behaviour, such as educator perceptions of reducing sedentary time (Ellis, Cliff, & Okely, 2017). Strong state and national level regulations and best practices are critical components in reducing sedentary behaviour.

Another part of translational research that is rarely reported is examining the effectiveness of interventions that have been scaled up to promote health behaviour among young children that have been previously tested under “ideal” conditions. The essential step for scalability is to implement interventions that have been successful from a controlled research condition (randomized controlled trials) in a more “real-world” environment (Milat, Bauman, Redman, & Curac, 2011). Implementation issues of an intervention are complex and have multiple barriers in that multiple aspects need to be taken into account including feasibility, acceptability, cost-effectiveness, and other environmental, organizational and political factors (Schmid, Jochem, & Leitzmann, 2018). To our knowledge there are no published studies that have examined the translation of findings from an efficacy trial to an effectiveness trial, which focuses on reducing young children’s sedentary behaviour in childcare settings. However, this has been done in 8-10 year old children from 20 primary schools over a 2.5-year period (Salmon et al., 2015). Preliminary results showed that The Transform-Us study, which involved both pedagogical and environmental approaches to reduce sedentary time, appeared to be sustainable; however the study reported there were challenges in translating the full program in terms of teacher training and equipment costs (Salmon et al., 2015). Besides evaluating the effect of an intervention, it is also essential to evaluate the process of the intervention as the variability in the effectiveness of an intervention can depend on the level of implementation (De Bourdeaudhuij et al., 2011). Future interventions should search for different implementation strategies, such as providing educators with more practical, easy and less time consuming activities that reduce sedentary behaviour. More research is needed to ensure successful translation of evidence based research/intervention programmes into real-life settings. Future research should focus on how to properly disseminate, implement and sustain efficacious interventions.

2.8 Summary

This literature review has provided an overview of the gaps in the research area of sedentary behaviour in young children. Childcare has been shown to be a key target setting to intervene as a large proportion of young children spend at least a day a week in formal childcare (Sisson et al., 2016), and evidence suggests that young children sit for almost 50% of their time at childcare (Ellis et al., 2016). However, there is a lack of prevalence data using direct objective measures of sitting in young children at childcare. The literature review showed that there is variability across studies on the proportion of sedentary time among young children at childcare. Ways to more accurately determine the amount of time young children spend sedentary in childcare are needed. Other types of measurements, such as activity monitors that directly and objectively measure sitting and can more accurately distinguish between different postures, should be used in future studies to measure sitting time in young children.

It is important to expand and strengthen the knowledge about both modifiable and non-modifiable correlates of young children's objectively measured sedentary time during childcare to prioritise key factors in the development of effective interventions. Interventions need to be informed by appropriate formative research with those who will implement interventions in childcare settings, that is the educators. With respect to the health consequences of sedentary behaviour in young children, this review indicates that there is a need for both acute experimental studies, to show immediate health effects of sitting, and longer intervention studies, demonstrating the chronic effects of reducing prolonged sitting time in young children at childcare. The childcare setting is a contained setting which has been shown to have a considerable effect on children's behaviour through policies and practices. These policies and practices are somewhat amendable to change. However, there are few childcare-based intervention studies targeting a reduction in prolonged sitting. These research gaps will be addressed throughout this thesis. The first study (next chapter) will investigate and describe the proportion of sitting time in young children at childcare, differences by demographic characteristics, and compliance with IOM recommendations for sedentary behaviour.

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Chapter 3

Sedentary Time, Physical Activity and Compliance with Recommendations among Young Children at Childcare

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3.1 Abstract

The aim of this study was to report patterns of sitting, standing and physical activity and compliance with Institute of Medicine (IOM) recommendations for sedentary behaviour and physical activity among children aged 1 to 5 years at childcare, and examine sociodemographic variations. Sitting, standing and physical activity time were assessed using an activPAL accelerometer over a period of 1 to 5 days in 301 children (49% boys; mean age=3.7±1.0 years) across 11 childcare services in Illawarra, NSW, Australia. Breaks and bouts of sitting and standing were calculated and categorized. Height and weight were assessed and parents completed a demographic survey. Differences by sex, age category (<3 vs ≥3years), weight status and SES were examined. Children spent 48.4% of their time at childcare sitting, 32.5% standing, and 19.1% in physical activity. Boys spent significantly more time in physical activity compared to girls (20.8% vs 17.7%; P =0.003). Toddlers (<3years) spent significantly more time in physical activity compared to pre-schoolers (≥3years) (22.2% vs 18.3%; P<0.001). Children who were underweight spent a significantly higher proportion of time sitting compared with their overweight peers (52.4% vs 46.8%; P=0.003). 56% and 16% of children met the IOM sedentary behaviour and physical activity recommendations, respectively. Girls (odds ratio[OR]; 95%CI=0.26;0.13 to 0.55) and pre-schoolers (0.16;0.07 to 0.38) were less likely to meet the IOM physical activity recommendation compared to boys and toddlers, respectively. Young children spent ~50% of their time at childcare sitting. Girls and pre-schoolers sit more and are less likely to meet physical activity recommendations, making them important groups to target in future interventions.

Keywords: *Accelerometry, Pediatrics, Sedentary lifestyle, Physical activity, Pre-school*

3.2 Introduction

Young children have high levels of sedentary behaviour and low levels of physical activity (Okely, Salmon, Trost, & Hinkley, 2008; Reilly, 2010). There is growing evidence that spending excessive time in sedentary pursuits, independent of the amount of moderate- to vigorous intensity physical activity (MVPA) undertaken, may be adversely associated with adiposity and cardio-metabolic health outcomes in children, particularly among those overweight, obese or at-risk of overweight and obesity (Cliff et al., 2014; Saunders et al., 2013). Furthermore, studies in adults have shown that standing and breaking up sitting time are beneficial for cardio-metabolic health (Healy, Winkler, Owen, Anuradha, & Dunstan, 2015; Júdice, Hamilton, Sardinha, Zderic, & Silva, 2016). Participation in physical activity during early childhood has been shown to be beneficial for health and development (Carson et al. 2015., Janssen and LeBlanc, 2010). However, among pre-schoolers it has been reported that around 73% of their waking hours are spent in sedentary behaviour (Salmon et al., 2011). And that this particular behaviour tracks from early childhood (aged 3-5 years) into childhood (aged 5-8 years) (Jones et al., 2013).

Several countries and organisations have acknowledged the importance of limiting prolonged sedentary time and increasing physical activity in young children (Canadian Society for Exercise Physiology, 2012; Department of Health, 2011; Department of Health and Aging, 2010). More recently, the Institute Of Medicine (IOM) in the US has provided specific recommendations around sedentary behaviour and physical activity for childcare or pre-school; stating that young children should be allowed to move freely and that sitting or standing still should be limited to 30 minutes at one time, and providing opportunities for children to participate in physical activity for at least 15 minutes per hour while in care (Institute of Medicine, 2011). Few studies have objectively examined the prevalence of sitting, standing and physical activity time among children while they attend childcare (Brown et al., 2009), none have examined how sitting varies by socio-demographic factors, which is important to determine if targeted interventions are required. Furthermore, limited data are available on compliance with current IOM recommendations (Pate et al., 2015). Only one study has objectively assessed physical activity at childcare, and it was conducted in the USA (Pate et al., 2015). Reporting international data from is important to understand prevalence rates across countries. Accelerometers worn on the waist are currently the most common method to measure sedentary behaviour and physical activity in children, however this approach has difficulties discriminating between sitting and standing still (Kozey-Keadle, Libertine, Lyden, Staudenmayer, & Freedson, 2011), which is important for accurately assessing sedentary behaviour. The activPAL is a unique device that is capable of detecting postures, particularly sitting and standing due to its placement on the thigh (De Decker et al., 2013).

The purpose of this study was to 1) report sitting, standing and physical activity among children aged 1-5 years in childcare; 2) investigate the differences in sitting, standing and physical activity and sitting and standing breaks and bouts by sex, age, weight-status and socio-economic status; and 3) determine the compliance with IOM recommendations for sedentary behaviour and physical activity among young children while they attend childcare using a posture-based motion sensor.

3.3 Methods

3.3.1 Study design

The Standing Pre-schools Project was a cross-sectional study of 11 childcare centres within the Illawarra and Shoalhaven regions of NSW, Australia (population. 0.4 million). Five of the 11 services were located in middle/high socio-economic status (SES) suburbs and six in low SES suburbs. The SES status of the centre suburb was based on the 2011 Socio-Economic Indices for Areas (SEIFA) Index of Relative Socio-Economic Disadvantage (Australian Bureau of Statistics, 2011). If the score of a suburb was located below the fourth decile, it was categorized as low SES, otherwise middle/high SES. Recruitment and data collection took place over a 6-month period (February-July, 2013).

3.3.2 Participants

All parents/guardians of 1- to 5- year-old children attending the childcare centres were invited to participate via a written information sheet and provided consent for their child to participate (Appendix B). To be eligible, a child needed to be independently mobile. This study received approval by the Human Research Ethics Committee at the University of Wollongong (HE12/443) (Appendix A).

3.3.3 Measures

Total time spent in sitting, standing and physical activity were assessed using an activPAL on each weekday that the child attended the service over a 1-week period. The activPAL has shown to be a valid measurement tool for discriminating between different postures in young children (Janssen et al., 2014). The activPAL was placed on participants' upper thigh (Davies et al., 2012; Janssen et al., 2014). Trained research assistants attached the activPAL as each child arrived at the service. The staff or parent/guardian removed the monitor when child departed childcare in the afternoon. On and off times were recorded by the research assistant or staff. After the monitors were collected from each service, data were downloaded and entered using activPAL software (v7.2.32). Fifteen second epoch files were used with the Centre for Physical Activity and Health Research (CPAHR) MATLAB program to calculate sitting/lying, standing, PA and non-wear time for each participant per day (Dowd, Harrington, Bourke, Nelson, & Donnelly, 2012). Times before arrival and departure were manually removed from the total minutes monitored. Naptime was excluded for toddlers and considered non-weartime, as it has been shown that over 90% of children this age still nap (Blair et al., 2012). This was not done for pre-schoolers as research suggests that nearly three-quarters of pre-schoolers do not sleep during nap time (Pattinson, Staton, Smith, Sinclair, & Thorpe, 2014). For a day to be considered valid, children needed to wear the activPAL ≥180 minutes and needed >1 valid day to be included in the analyses (Byun, Liu, & Pate, 2013). Sitting breaks and bouts were determined from activPAL outputs. Mean breaks per hour of sitting were calculated as the total sum of all the number of bouts (Dowd et al., 2012). Bouts of sitting were categorised as: <1minutes, 1-4minutes, 5-9minutes, 10-19minutes, 20-29minutes, or ≥30minutes (Carson, Stone, & Faulkner, 2014). Compliance with the IOM sedentary behaviour recommendation was derived by calculating the combined sitting and standing bouts ≥30minutes from the event file. Children without a sitting and standing bout ≥30minutes were categorised as complying with the recommendation. To report if children spent 15 minutes in PA per hour, their percentage needed to be ≥25% per hour.

Children aged 1.0 to 2.9 years were categorized as toddlers, and 3.0 to 5.9 years as pre-schoolers. Each child's date of birth and sex were collected on the consent form. Height and weight were measured using a portable stadiometer (PE87; Mentone Educational Centre) and a calibrated electronic weight scale (Tanita BF-681; Tanita Corporation of America), according to standardised protocols (Wake, Salmon, Waters, Wright, & Hesketh, 2002). Body mass index (BMI: kg/m^2) and weight status was calculated using LMSGrowth (Medical Research Council, United Kingdom) and UK reference curves (Cole, Freeman, & Preece, 1995). Children >2 years were categorized as underweight, normal weight, overweight, or obese based on the IOTF (International Obesity Task Force) age- and gender-specific cut-points (Cole et al., 1995). For children <2 years, percentiles were calculated and categorized in weight statuses using UK reference curves (Cole et al., 1995).

3.3.4 Sample Size and Power

The sample size was calculated based on the ability to provide a reliable estimate of the time spent sitting and to detect differences between demographically defined groups. These estimates were calculated based on a relative standard error of <25% (Booth et al., 2015) using the formula: $N = pq/s^2$, where N = sample size; p = estimated prevalence; q = 1 – p; and s = required SE of the prevalence statistic. Based on our feasibility study, it was highly unlikely that a child would spend <10% of the day in childcare sitting, requiring 144 children per day to be sampled. As the childcare centre was the unit of observation, the sample size was increased by a design effect of 1.5 – to 216 children – to account for clustering.

3.3.5 Statistical analyses

Analyses were performed in STATA 13 and SPSS21. Descriptive statistics were calculated using means and standard deviations for continuous variables and frequencies and percentages for categorical variables. To determine if differences existed in proportion of sample size within sex, age, weight status and SES, independent samples t-tests or Mann-Whitney *U*-tests were used. Mixed linear regressions were used to examine the difference between sitting, standing and physical activity time by sex, age, weight status and SES of centre and to calculate the intraclass correlation coefficient across the centres. To account for the clustered nature of the data, the models included childcare centre as a random effect. Fixed effects such as age, sex and weight status were included as covariates in the mixed models when they were not the predictor being tested. Differences in breaks and bouts between boys and girls; toddlers (1-2 years) and pre-schoolers (3-5 years); underweight, normal weight, overweight and obese children; and low and medium SES groups were examined using linear regression and repeated measures ANOVA. To interpret the differences in percentages of children meeting sedentary behaviour and physical activity recommendations, odds ratios were calculated by using a logistic regression.

3.4 Results

Descriptive characteristics are reported in Table 3.1. Of the 799 eligible 1- to 5-year-old children from 11 childcare centres, 550 children (68%) provided parental consent. Of these, 3 children were absent and 28 children declined to participate on the day of testing, 81 children did not have height and weight measured, and 6 monitors were not returned. Data from 145 children were excluded due to no monitor data, a download error, monitor malfunction or children not meeting criteria of wearing monitor for at least 50% of their time spent at childcare, which left data for 301 children (55% response rate; 52% girls, 23% overweight/obese) for analysis. No significant differences were found in socio-demographic characteristics between the included and excluded groups (*P*=0.89). Among the 301 participants, the average monitor wear time was 1.8 days (±0.9) and 308.6 (±76) minutes/day. Boys and girls wore the accelerometers on average for 1.8 days (±1.0) and 1.8 days (±0.8), respectively. No significant differences were found in wear time between boys (307.3, 56% minutes/day) and girls (309.8, 57% minutes/day) (see Table 3.1).

Table 3. 1 Descriptive characteristics of participants, Illawarra NSW, Australia, 2013.

Characteristics	**Total (n=301)**	**Boys (n=145)**	**Girls (n=156)**
Age (y), mean (SD)	3.7 (1.0)	3.7 (1.0)	3.7 (0.9)
Toddlers (1-2.9) (n=68), mean (SD)	2.2 (0.5)	2.2 (0.6)	2.3 (0.4)
Pre-schoolers (3.0-5.9) (n=233), mean (SD)	4.1 (0.6)	4.2 (0.6)	4.1 (0.6)
Weight status*			
Underweight (n, %)	6 (19)	10 (7)	9 (6)
Normal weight (n, %)	213 (71)	98 (67)	115 (74)
Overweight (n, %)	18 (53)	30 (21)	35 (15)
Obese (n, %)	5 (14)	5 (4)	9 (6)
Socio-economic status			
Low-income (n, %)	155(52)	82 (57)	73 (47)
Middle/high-income (n, %)	146 (48)	63 (43)	83 (53)
Wear time			
Days (n±se)	1.8 (0.9)	1.8 (1.0)	1.8 (0.8)
Wear time min/d (mean, SD)	309 (76)	307 (79)	310 (74)

* Under 2 yrs: underweight <5 percentile, normal weight 5-85 percentile, overweight 85-95 percentile, obese >95 percentile

Sitting, standing and physical activity

The estimated time spent in sitting, standing and physical activity by sociodemographic are presented in Table 3.2. On average, children spent 48.3% of their day in childcare sitting, 32.5% standing and 19.1% in physical activity. Boys spent significantly more time in physical activity per day compared to girls (P=0.03). Toddlers spent significantly less time sitting and significantly more time standing and being physical active compared to pre-schoolers (P<.001). Children who were underweight spent significantly more time sitting than their overweight peers (P=0.03).

Table 3. 2 Time spent in sitting, standing and physical activity (mean %, SE), Illawarra NSW, Australia, July 2013.

Characteristics	No.	Sitting	95% CI	P	Standing	95% CI	P	PA	95% CI	P
ICC		0.11			0.02			0.14		
Total sample	301	48.3 (0.7)			32.5 (0.5)			19.1 (0.4)		
Sex [a]										
Boys	146	47.2 (1.5)	43.9-50.8	0.22	32.0 (0.8)	30.2-33.8	0.34	20.8 (0.5)	18.5-22.9	<0.003
Girls	155	49.3 (1.5)	45.8-52.5		33.0 (1.0)	30.9-35.2		17.7 (0.4)	16.2-19.4	
Age [b]										
Toddlers (1-2.9)	71	40.3 (1.4)	35.0-39.9	<0.001	37.4 (1.1)	34.9-39.9	<0.001	22.2 (1.1)	20.1-24.2	<0.001
Pre-schoolers (3.0-5.9)	230	50.6 (0.7)	29.2-33.0		31.1 (0.5)	29.2-32.9		18.3 (0.4)	16.6-20.1	
Weight status [c]	299									
Underweight	19	52.4 (2.0)	47.9-56.9		28.8 (1.7)	26.3-33.6		17.2 (1.5)	13.7-21.7	
Normal weight	215	48.2 (1.3)	45.4-51.1		32.8 (0.7)	31.0-34.3		19.1 (0.8)	17.4-20.8	
Overweight	51	46.8 (2.3)	41.8-51.8	0.03 [d]	33.0 (1.2)	29.6-36.8		20.3 (0.9)	17.9-22.3	
Obese	14	46.7 (3.8)	39.2-54.8		33.7 (2.3)	29.1-37.4		19.6 (1.8)	15.3-24.3	
Socio-economic status [c]										
Low	155	46.5 (0.9)	41.8-51.3	0.93	33.6 (0.7)	31.4-35.8	0.67	19.9 (0.5)	17.2-22.6	0.45
Middle/high	146	50.1 (1.2)	47.5-52.6		31.5 (0.5)	29.9-33.0		18.5 (0.5)	16.8-20.15	

Analyses adjusted for clustering, ICC=I*ntraclass Correlation* Coefficient [a]Adjusted for age category, [b]Adjusted for sex [c]Adjusted for sex, age
[d]Underweight compared to overweight

Sitting breaks and bouts

The total number of sitting breaks and bouts per hour are shown in Table 3.3. On average, children accumulated 11.9 ± 3.0 breaks per hour. Breaks per hour did not differ by demographic characteristics. On average, 95% of children's sitting bouts were <10 minutes. The average number of <1 minute sitting or lying bouts/hour was significantly higher in boys compared to girls ($P < 0.001$), toddlers compared to pre-schoolers ($P < 0.001$), low compared to middle/high SES children ($P < 0.05$), obese compared to normal weight children ($P = 0.003$), and overweight compared to normal weight children ($P = 0.01$). Underweight children had significantly more <1 minute bouts compared to normal weight, overweight and obese children ($P < 0.001$). The number of 5-9 minute bouts was significantly greater in pre-schoolers compared to toddlers ($P = 0.02$). The number of 10-19 minute, 20-29 minute or ≥30 minute sitting bouts per hour did not differ by demographic characteristics.

Compliance with IOM recommendations is shown in Table 3.4. Of the 301 children, 56% met the IOM recommendation for sedentary behaviour. Only 16% of children met the IOM physical activity recommendation. Girls (0.26;0.13-0.55), pre-schoolers (0.16;0.07-0.38) and children from middle/high SES (0.71;0.36-1.41) were less likely to meet the IOM physical activity recommendation compared to boys, toddlers and participants from low SES, respectively.

Table 3. 3 Differences in mean (SD) number of breaks and bouts of sitting per hour by demographics, Illawarra NSW, Australia, July 2013.

Characteristics	**Breaks in sitting per hour**	**Bouts of sitting per hour**					
		<1min	**1-4min**	**5-9min**	**10-19min**	**20-30min**	**>30min**
Total sample	11.9 (0.3)	6.3 (2.1)	4.1 (1.3)	0.9 (0.4)	0.5 (0.3)	0.1 (0.1)	0.1(0.1)
Sex							
Boys	12.0 (0.3)	6.5 (2.4)*	4.0 (1.3)	0.9 (0.4)	0.5 (0.3)	0.1 (0.1)	0.0 (0.1)
Girls	11.9 (0.4)	6.1 (1.9)	4.2 (1.4)	1.0 (0.4)	0.5 (0.3)	0.1 (0.1)	0.1 (0.1)
Age							
Toddlers (1-2.9)	12.0 (0.3)	6.8 (2.4)*	4.0 (1.7)	0.7 (0.4)*	0.3 (0.3)	0.08 (0.1)	0.0 (0.1)
Pre-schoolers (3.0-5.9)	11.9 (0.3)	6.2 (2.0)	4.1 (1.2)	1.0 (0.4)	0.5 (0.3)	0.1 (0.1)	0.1 (0.1)
Weight status							
Underweight	11.5 (0.4)	5.6 (2.1)**	3.9 (1.4)	0.9 (0.5)	0.6 (0.1)	0.2 (0.2)	0.1 (0.1)
Normal weight	12.0 (0.3)	6.3 (2.1)***	4.1 (1.3)	0.9 (0.4)	0.5 (0.3)	0.1 (0.1)	0.1 (0.1)
Overweight	12.1 (0.4)	6.5 (2.2)	4.2 (1.3)	0.8 (0.5)	0.5 (0.5)	0.1 (0.5)	0.1 (0.1)
Obese	11.7 (0.5)	6.9 (1.8)	4.1 (1.3)	0.8 (0.6)	0.3 (0.2)	0.2 (0.2)	0.0 (0.1)
Socio-economic status							
Low	12.2 (0.2)	6.7 (2.2)*	4.1 (1.4)	0.9(0.4)	0.4 (0.3)	0.1 (0.1)	0.1 (0.1)
Middle/high	11.7 (0.2)	5.9 (2.0)	4.1 (1.3)	1.0(0.4)	0.5 (0.3)	0.1 (0.1)	0.1 (0.1)

Analyses (linear regression and repeated measures ANOVA) adjusted for clustering, *P<0.001, **P<0.001 underweight vs normal weight, overweight, obese, ***P=0.01 normal weight vs obese

Table 3. 4 Percentage of children achieving the IOM recommendations for sedentary behaviour (Alhassan, Nwaokelemeh, Lyden, Goldsby, & Mendoza) and physical activity (PA) by socio-demographic factors, Illawarra NSW, Australia, July 2013.

Characteristics	No.	Number of Sitting and/or Standing bouts >30 min/day Mean (SD)	IOM Recommendation SB (%)	OR (95% CI) unadjusted	OR (95% CI) adjusted	IOM Recommendation PA (%)	OR (95% CI) unadjusted	OR (95% CI) adjusted
Total sample	301	0.4 (0.7)	56			16		
Sex[1]								
Boys	146	0.4 (0.6)	59	1.00 (ref)	1.00 (ref)[a]	24*	1.00 (ref)	1.00 (ref)[a]
Girls	155	0.5 (0.7)	53	0.78 (0.49, 1.23)	0.78 (0.50, 1.30)[a]	8	0.29 (0.14, 0.57)	0.26 (0.13, 0.53)[a]
Age[2]								
Toddlers (1-2.9)	71	0.3 (0.8)	63	1.00 (ref)	1.00 (ref)[b]	37**	1.00 (ref)	1.00 (ref)[b]
Pre-schoolers (3.0-5.9)	230	0.4 (0.6)	54	0.68 (0.39, 1.19)	0.53 (0.23, 1.21)[b]	10	0.19 (0.09,0.36)	0.16 (0.07, 0.38)[b]
Weight status[3]	299							
Underweight	19	0.5 (0.5)	58	1.11 (0.43, 2.86)	1.28 (0.34, 4.74)[c]	11	0.64 (0.14, 2.91)	0.95 (0.19, 4.50)[c]
Normal weight[4]	215	0.4 (0.4)	55	1.00 (ref)	1.00 (ref)[c]	16	1.00 (ref)	1.00 (ref)[c]
Overweight	53	0.4 (0.4)	55	0.97 (0.53, 1.78)	0.82 (0.35, 1.92)[c]	19	1.27 (0.58, 2.77)	1.15 (0.48, 2.73)[c]
Obese	14	0.3 (0.3)	64	1.45 (0.47, 4.47)	0.98 (0.16, 6.21)[c]	21	1.49 (0.39, 5.62)	1.61 (0.36, 7.14)[c]
Socio-economic status[3]								
Low-income	155	0.3 (0.5)	63	1.00 (ref)	1.00 (ref)[c]	19	1.00 (ref)	1.00 (ref)[c]
Middle/high income	146	0.5 (0.7)	49	0.58 (0.37,, 0.92)	0.59 (0.37, 0.94)[c]	13	0.65 (0.35, 1.22)	0.71 (0.36, 1.41)[c]

CI = confidence interval; OR = odds ratio.
Logistic regression with unadjusted and adjusted analyses
[a]Adjusted for age category, [b]Adjusted for sex, sex*age category, [c]Adjusted for sex, age category, [d] Normal weight compared to other weight statuses, * Significant difference between sexes (P<0.001), **Significant differences between age category (P<0.001)

3.5 Discussion

To our knowledge, this is one of the first studies to report on both objectively measured sedentary time, where sitting is distinguished from standing, physical activity in young children at childcare and to report compliance with both the IOM sedentary behaviour and physical activity recommendations. We found that children aged 1 to 5 years spent around half of their total time at childcare sitting, one-third standing, and one-fifth being physically active. We also found significant differences in sitting, standing and physical activity by socio-demographic factors. Specifically, boys spent more time in physical activity compared to girls, and toddlers spent less time sitting and more time standing and being physically active compared to pre-schoolers. Further, pre-school children had significantly greater 5-9 minute sitting bouts compared to toddlers. Approximately half of the children met the IOM recommendation for sedentary behaviour, but less than one in five children met the IOM recommendation for physical activity.

Previous studies have reported children's sitting or sedentary time during childcare (Brown et al., 2009; Carson, Salmon, Crawford, Hinkley, & Hesketh, 2016; Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004; Tandon, Saelens, & Christakis, 2015), one of which also examined standing time (Brown et al., 2009). Using hip-mounted accelerometers, Carson et al. (2016) reported that young Australian children were sedentary for 48% of their time at childcare, which is consistent with the current study. Brown et al. (2009) used direct observation and reported a lower proportion of time sitting (43%) and standing (15%) than the current study. Methodological differences might explain the contrasting findings for standing time. The current study and Carson et al. (2016) used accelerometry, whereas Brown et al. (2009) used direct observation. During this observation, a focal child, momentary time sampling strategy was used, where a pre-selected child was individually observed for 30 minutes. Accelerometers collect data on each individual child while direct observation typically collects data on a randomly selected subset of children. Additionally, only standing still was coded as standing in Brown et al.'s (2009) study. If children were standing stationary but performing another activity, such as throwing, dancing or climbing, this was categorised as an alternative activity rather than standing. However, in the current study the activPAL would have coded this as standing. Collectively, these studies indicate that young children spend close to half their time sitting and between 20% - 30% of their time standing while at childcare.

Few studies have examined the time spent in physical activity among children at childcare. However, given that stepping (output activPAL) represents activity of a similar intensity to light-,moderate- and vigorous-intensity physical activity (LMVPA), which is the intensity identified in physical activity recommendations for young children (Canadian Society for Exercise Physiology, 2012; Department of Health, 2011; Department of Health and Aging, 2010), the results can be compared with other studies that have reported the proportion of time spent in LMVPA at childcare. Brown et al. (2009) reported that 8% of total intervals by activity levels was spent in light activity and 3% in MVPA, resulting in a total proportion of time in LMVPA of 11%, which is 7% less compared to the current study. Pate et al. (2008) used the Actigraph over two weeks and showed that children in pre-school spent 17.5% of their hour in light activity and 13% in MVPA, which is a total of 30.5% spent in LMVPA per hour. This is 12% more compared to the present study. Differences in sample characteristics may explain the differences in findings between the current study and Pate et al.'s (2004, 2008, 2015). One other study (Pate et al., 2015) reported the prevalence of compliance with IOM physical activity recommendation for pre-school children in two independent samples (41.6% and 50.2%), which is roughly three times higher than the current study. Methodological differences might explain these large differences. Pate et al. (2015) used a hip-mounted Actigraph to measure physical activity, while the current study used an activPAL. Pate et al. (2015) also measured physical activity across the whole day during and outside of childcare hours, whereas assessments in the current study were completed only during childcare hours. As such, the results for our sample suggest that physical activity levels during childcare were low and may require intervention.

Consistent with previous studies, boys were more active than girls (Finn, Johannsen, & Specker, 2002; Jackson et al., 2003; McKenzie, Sallis, Nader, Broyles, & Nelson, 1992). Furthermore, boys were more likely to meet the IOM physical activity recommendation compared to girls, which is consistent with Pate et al. (2015). An explanation for these findings is that certain observational studies of pre-school children indicate that boys engage in more vigorous intensity activities, play in larger groups in more open settings, and engage in more risk-taking behaviour (Eaton & Enns, 1986; Hoffmann & Powlishta, 2001). This could explain why boys in our sample spent more time in physical activity. This finding is useful for educators and paediatricians in their role of promoting physical activity for young children, with an additional focus on girls during the early years.

No studies have looked at the difference in activity levels between toddlers and pre-schoolers in childcare. Gubbels et al. (2011) showed activity levels of 2- and 3-year-old children, without any differences. However, a previous study has reported that children of 3 year old were more active compared to 4- and 5-year-olds (Pate, McIver, Dowda, Brown, & Addy, 2008). Pate et al. (2008) showed that in particular, 3-year-old boys were more active than 4- and 5-year-old children: however, this difference was not observed for girls. Children aged 4 and 5 years also spent more time in sedentary pursuits compared to 3-year-old children (Pate et al., 2008). A possible explanation could be that 4- and 5-year-old children undertake more structured activities to prepare them for elementary school, resulting in more time spent sitting and less time being physically active. This could explain our other findings that pre-schoolers accumulated more 5-9 minute bouts compared to toddlers, and that toddlers are more likely to meet the physical activity recommendation. These results suggest a balance is needed between meeting children's educational and health needs to reduce sitting. At this stage the optimal length of a bout of sitting time and how frequently sitting time should be broken up in young children is not known. However, providing children with the choice to break-up sitting time while at childcare is important. Possible modifications could involve children work at standing-desks to complete academic activities such as writing, drawing or reading.

To the authors' knowledge no studies have measured differences in sitting time by weight status in young children at childcare. There were no differences between normal weight and other weight groups. We found that underweight children (n=19) had higher levels of sitting compared to overweight children (n=51), although the small number of children included in each group may have contributed to these findings. Another possible explanation for this counterintuitive result might be potentially poorer physical and motor development, which supports participation in active play among underweight children compared to normal weight children (Roberts, Veneri, Decker, & Gannotti, 2012). Young children with poorer motor skills demonstrate more time in sedentary behaviour and less time in physical activity (Williams et al., 2008).

Recent recommendations around sedentary behaviour at childcare from the IOM suggest that young children should be allowed to move freely and sitting or standing should be limited to 30 minutes at a time (Institute of Medicine, 2011). Just over half of the children (56%) met the IOM recommendation for sedentary behaviour. There are no other studies that have confirmed this finding. This reinforces that childcare services should implement activities to encourage children to move and walk more frequently as part of their daily routines. Furthermore, the current IOM recommendation for sedentary behaviour is different compared to the widely accepted definition of sedentary behaviour from the Sedentary Behaviour Research Network (Sedentary Behaviour Research Network, 2012). This presents a challenge for researchers and practitioners in the assessment and operationalization of these recommendations in practice. It is suggested that this inconsistency is resolved in the near future by developing a recommendation based on the definition for sedentary behaviour.

The strengths of the current study include the use of an objective and direct measure to assess sitting, standing and PA, thus overcoming some of the limitations in other assessment methods. Second, the large and diverse sample from different geographical areas including children aged less than three years, for which there is limited evidence in the literature, strengthens the generalisability of the findings.

Third, sedentary behaviour and physical activity were only assessed in the childcare setting, which allowed the assessment of compliance with the IOM recommendation. Limitations include the low response rate, because a considerable proportion of the consented children had to be excluded due to not having all required valid data. This was mainly because the weartime was shorter than we had hoped. An explanation for the short wear time was due to the activPAL garter falling down in many of the children. This issue was resolved towards the end of data collection by using double sided tape on the inside of the garter. Furthermore, the inclusion of nap time for the small proportion of pre-schoolers who might still nap may have impacted on the estimates of their behaviours.

3.6 Conclusion

In conclusion, young children in our sample spent approximately half of their time sitting while at childcare, and only a small proportion meet childcare based physical activity recommendations. Strategies to replace or break-up sitting time with more standing and LMVPA are warranted, particularly in girls and pre-school aged children. Implementing changes in policies, practices, and environments within the childcare service are imperative to reduce total sitting time and increase physical activity.

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Chapter 4

Childcare educators' perceptions of and solutions to reducing sitting time in young children: a qualitative study

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4.1 Abstract

Young children spend a high proportion of their time at childcare sitting. Reducing sitting time or breaking up prolonged periods of sitting may be positively associated with health outcomes among children. The purpose of this study was to identify childcare educators' perceptions of what environmental and policy modifications could be made within early childhood education and childcare settings to reduce sitting time among children during childcare. Eighty-seven educators from 11 childcare centres participated in 11 focus groups between September 2013 and November 2013. Each focus group was audio-recorded and transcribed verbatim. A semi-structured schedule was developed to investigate the educators' perceptions of the influences on children's sitting time at childcare. A problem-solution tree was developed to determine potential solutions for reducing total and prolonged sitting time in young children at childcare. Most educators were unaware of the high levels of sitting time among young children. Educators identified that childcare practices, the physical environment and the weather were factors that influenced children's sitting time. Potential solutions to reduce sitting time were to break-up prolonged sitting time by using movement breaks, standing desks, movement transitions between activities, relocating key facilities around the space to promote movement, and integrating movement during learning activities. Also, educators suggested that posters could be used to increase awareness among educators about the benefits of reducing sitting time. Educators identified key practices that could be modified to reduce young children's sitting time in childcare. These potential solutions should be evaluated to understand their effectiveness.

Key words: *Pre-school, Physical Activity, Toddlers, Sitting, Qualitative research*

4.2 Introduction

The early years are a critical period of development; it signifies an important period in the establishment of sedentary behaviour and physical activity habits for both current and later health (Janz, Burns, & Levy, 2005). Sedentary behaviour is defined as “any waking activity characterized by an energy expenditure of ≤1.5 metabolic equivalents and a sitting or reclining posture” (p. 540) (Sedentary Behaviour Research Network, 2012). Currently, young children spend high proportions 40 to 80% of their waking time in sedentary behaviour (Colley et al., 2013; Ellis et al., 2016; Reilly, 2010; Salmon, Tremblay, Marshall, & Hume, 2011). Although the evidence appears to be inconsistent (Cliff et al., 2016), some research suggests that, independent of the amount of moderate- to vigorous-intensity physical activity (MVPA) undertaken, prolonged sedentary behaviour may be adversely associated with health outcomes in children, particularly children who are overweight or obese (Cliff et al., 2014; Mitchell, Pate, Beets, & Nader, 2013; Saunders et al., 2013), which includes 41 million children under the age of 5 worldwide (WHO, 2016). Reducing sedentary behaviour (either decreasing overall sitting time or breaking up prolonged sitting) has shown to have a beneficial effect on important markers of cardio-metabolic health in children (Saunders et al., 2013).

Internationally, more than 80% of 3- and 4-year-olds and around one-third of 1- and 2-year-olds spend at least one day a week at childcare (OECD - Organization for Economic Cooperation and Development, 2014), and so this setting is important in shaping children’s sedentary habits (Ward, Vaughn, McWilliams, & Hales, 2010). Therefore, childcare is being positioned as a potential system for intervention in the general public health problem of physical inactivity. Sedentary behaviour recommendations have been developed for children at childcare (Institute of Medicine, 2011). These recommend that young children should be allowed to move freely and that sitting or standing still should be limited to 30 minutes at a time (Institute of Medicine, 2011). A recent study (shown in Chapter 3) in 11 childcare settings in Australia showed that nearly half of the pre-schoolers and one third of the toddlers in childcare did not meet this recommendation and that they spent approximately 50% of their childcare day sitting (Ellis et al., 2016). As such, it is important to identify why children spend high proportions of time sitting in childcare settings and what can be done to reduce this. A recent systematic review of quantitative studies investigating the correlates of children's sedentary behaviour in childcare settings found that the most significant influence was the physical environment (Tonge, Jones, & Okely, 2016).

There are limited qualitative studies examining educators' perspectives of the factors that may influence sitting time in childcare centres (De Decker et al., 2013; Määttä, Ray, Roos, & Roos, 2016). In this setting, childcare educators' have an important role in shaping children's sedentary behaviour, as they are primarily responsible for the policies, practices and environments at childcare. Identifying childcare educator's perceptions of the potential solutions for reducing children's sitting time is important as it may result in the development of effective and solution-oriented interventions for decreasing sitting time among young children (De Decker et al., 2013; Robinson & Sirard, 2005).

The aim of this study was to understand early childhood educators' perceptions of young children's sitting time in childcare, the potential factors that contribute to high levels of sitting and potential modifications that could be made within childcare centres to reduce total and prolonged sitting among children during childcare.

Specifically, the following research questions were addressed:

1. What are educators' perceptions of the amount of time children spend sitting in childcare centres?
2. According to educators, what factors may contribute to children's sitting time in childcare centres?
3. According to educators, what are the potential solutions to reduce children's sitting time in childcare centres?

4.3 Methods

4.3.1 Participants

Using community-based participatory research methods (Israel, Schulz, Parker, & Becker, 2001), this qualitative study involved focus groups with educators, from 11 childcare centres within the Illawarra and Shoalhaven regions of NSW, Australia (population. 0.4 million). All directors from these childcare centres agreed to run a focus group. Focus groups with childcare directors, educators and central administration staff were held in each childcare centre during staff meetings and took place over a three-month period (August-October, 2013) as part of the Standing Pre-school Study (Ellis et al., 2016). This study focused on young children's sitting time at childcare and how to break up prolonged sitting.

Five of the 11 centres were located in middle socio-economic status (SES) suburbs and six in low SES suburbs. The SES status of the centre suburb was based on the

2011 Socio-Economic Indices for Areas (SEIFA) Index of Relative Socio-Economic Disadvantage (Australian Bureau of Statistics, 2011). If the score of a suburb was located below the fourth decile, it was categorized as low SES, otherwise middle SES. This study received approval by the Human Research Ethics Committee at the University of Wollongong (HE12/443) (Appendix A).

4.3.2 Data collection

Two female researchers facilitated all 11 focus groups. Each educator was asked to provide written informed consent prior to the focus groups (Appendix C). Focus groups lasted between 40 and 60 minutes (mean = 50.11min). Each of the focus groups was audio-recorded and transcribed verbatim. In addition, key points, which were not captured on tape, such as body language, were written down at the time by the researcher to capture important contextual information from the focus groups.

A semi-structured schedule was developed based on the problem-and solution tree tool (Snowdon, Schultz, & Swinburn, 2008) to examine the educator's perceptions of the causes of and potential solutions for modifying young children's high sitting time in childcare. The problem-and-solution tree tool has successfully been used in health research (Snowdon et al., 2008). At the beginning of each focus group for each centre, children's sitting, standing and stepping time data from phase I of the Standing Pre-school Study were reported back to the specific centre (Ellis et al., 2016). Each focus group then worked their way through the following steps as per the problem and solution tree approach: 1) reached agreement that current rates of total and prolonged sitting their childcare centre were too high; 2) identified factors (e.g. policy, physical and social environment) that contributed to this problem; 3) brainstormed solutions (positives) to the causes of the factors identified in Step 2 (negatives); 4) prioritised the identified solutions based on feasibility and acceptability; and 5) included any "floating" solutions not linked to a specific problem factor but considered by the group to be important.

4.3.3 Data management and analyses

The digital audio files from each focus group discussion were transcribed verbatim. Data analysis followed by the guidelines for thematic analysis outlined by Braun and Clarke (2006). To enhance trustworthiness of the analysis a "critical friend", a colleague who was not involved in the project, was used to provide feedback on the process of the analysis (Sparkes & Smith, 2014). The lead author read and listened to the audio recording to become familiarised with the data. Each transcript was then coded thematically; this was an open coding process, whereby meaningful quotes or key examples from educators were assigned a code. These "emergent" codes were then grouped together to develop themes (Braun & Clarke, 2006). Once themes were developed, the second and third author provided critical feedback on the analysis and interpretations of the study. The peer debrief was concerned with the on-going process of data collection and analysis. This process took place through regular meetings between the research team.

4.4 Results

A total of 87 childcare educators participated in the study and each focus group had between 3 and 10 participants, of which 99% were female.

Step 1: What are educators' perceptions of the amount of time children spend sitting in childcare centres? (Table 4.1)

In all focus groups, the average proportion of sitting, standing and stepping time for all children (toddlers and pre-schoolers) in each childcare centre were reported back to educators from that centre. The educators gave their initial perceptions on the amount of time spent sitting in their childcare centre.

1.1 Lack of awareness

The majority of educators were surprised that around half of children's time at childcare was spent sitting, as the common perception was that children were considerably active throughout the day (1.1.1, 1.1.2). Furthermore, educators were also not aware of the benefits for children of standing and spending more time in light-intensity physical activity, or the potential consequences of prolonged bouts of sitting (1.1.3).

1.2 Acknowledgement of findings

The educators generally accepted the findings that girls spent more time sitting than boys (1.2.1) and that pre-schoolers would sit for longer periods of time compared to toddlers, as pre-schoolers tended to find something to do and sit down to do it (1.2.2). All educators agreed to consider potential solutions to reduce young children's sitting time (1.2.3).

Table 4. 1 Quotations from educators for Step1: What are the educator's perceptions on young children's sitting time?

1.1	**Lack of awareness**
1.1.1	Yes, I am surprised with the results, it is a surprise. Because we do think they do so much moving throughout the day
1.1.2	60% at first, I thought wow, it would be good to get it down a little.
1.1.3	I just didn't know if we were benefitting the children when we do remove the chairs and standing how, you know, is benefitting them
1.2.1	It wouldn't surprise me yeah, they are more into their drawings, painting and craft sort of things yeah. While the boys would rather be outside kicking the ball.
1.2.2	I sort of can see when the babies don't sit as much as the pre-schoolers, because the pre-schoolers will find something to do and sit down.
1.2.3	I would love to see 35% sitting time, because they will do enough sitting when they get to school.

Step 2: According to educators, what factors may contribute to children's sitting time in childcare centres? (Table 4.2)

The next step was to identify any factors that would contribute to high sitting time. Educators identified that the childcare routine, physical environment, parent and educator values were the strongest factors.

2.1 Childcare practices

When considering the factors that may contribute to high levels of sitting among children in childcare, childcare practices was the most common theme identified by educators. Some educators mentioned that prolonged periods of sitting occur especially during the morning activities, and that there is a need to try and break this up. Moreover, one educator highlighted that in the early afternoon period there were activities in which sitting occurred for longer lengths of time (2.1.1). Another activity, which is often a part of the morning and afternoon routine, is story time. Educators recognized this as an activity in which children would remain seated throughout its duration (2.1.1). Group time, which typically involves gathering the children to share learning experiences, was also mentioned by most educators as one of the times in their daily routine where a lot of sitting occurred (2.1.2). During rest or nap time, educators reported that children were mainly involved in quiet sitting activities, such as puzzles, or drawing sitting down at a table (2.1.3) if they were not napping. Some educators suggested that compared with toddlers, pre-schoolers tended to have higher concentration levels and this was a reason why they spent longer lengths of time sitting down (2.1.3). In addition, educators mentioned that during social times, such as mealtimes, children were required to sit (2.1.4).

2.2 Physical and natural environment

The physical environment was noted by several educators as one of the key factors influencing high levels of sitting, specifically the lack of adequate outdoor space (2.2.1). Another natural environmental factor discussed by the educators was bad weather along with shorter days during winter, both of which they felt acted to limit children's physical activity outside and increased sitting time indoors. Moreover, educators indicated that the difference between summer (daylight savings) and winter routines could have an influence on children's sitting time, as the length of time children spent outside was longer during the summer routine (2.2.2, 2.2.3, 2.2.4).

2.3 Parental and educator values

Educators stated that parents' values and expectations influenced the activities completed at childcare, which may subsequently influence children's sitting time. First, educators perceived that parents want their child to rest, which usually involves sitting or lying down (2.3.1). Secondly, educators perceived that "school readiness" was an area that was highly salient for parents. According to educators, parents want their children to "be ready" for school, and therefore felt that children needed to learn to sit at a table at an early age (2.3.2). Likewise, some educators reported they wanted the children ready for school (2.3.3). A common view by educators was that concentrating requires sitting, and therefore group time usually included sitting. Furthermore, educators expressed that sitting is often used as a boundary, highlighting that it calms children down (2.3.4).

Table 4. 2 Quotations from educators for Step 2: Which factors did educators identify that contributed to high sitting time?

2.1	**Childcare practices**
2.1.1	They also get to scrape all their fruit. So, they can pour their own drinks. Sit down lunch is served and they eat their lunch. And then they go up and scrape their bowl, and then they will come sit back down for fruit. When they done that they'll go straight to story and sit down. And from there they then do Storytime and relaxation and they do quiet activities which is generally always at the table. – Predominantly sitting down
2.1.2	Group time is where a lot of sitting times comes from
2.1.3	They can spend rest time for an hour in one area; it can be here at the writing centre, creating and making or moulding things, or at a game table or puzzle table. Their concentration has expanded and they spend a long length of time sitting down
2.1.4	Like in the mealtime, so that is morning tea, lunch and afternoon tea, they are all sitting times. They need to be sitting times.
2.2	**Physical and natural environment**
2.2.1	But I do think the problem is the lack of space, because when you get these kids that are full on.
2.2.2	Like we said being into our summer routine we are in the yard earlier in the morning. Longer time out there to run around to play.
2.2.3	Because daylight savings, we can't be outside in the middle of the day. I guess there is more room to move outside, which means they might be more active.
2.2.4	This afternoon too, now that it is getting warmer the kids are getting so much more involved in the gardening and the watering and walking around so its weather conditions connected as well
2.3	**Parent and educator values**
2.3.1	And I guess the other one too like the rest and relaxation would be a big one where they probably be sitting a lot, but we have tried to start incorporating Thai chi and yoga and more of those sorts of things. But on the flipside of that too parents do want their children to rest.
2.3.2	I guess its finding a balance between the because half especially for the pre-school routine we get a lot of our parents want them to get ready for school, like, so and they do have to sit at a table and concentrate at times at school so that's what the focus group sometimes tend to be, especially the morning ones. So, I think that it would be quite difficult to get away from that"
2.3.3	I was just thinking of the older ones, because of school readiness, you got to get them ready to sit. It's about proper preparation and transition too.
2.3.4	Often, we tell children when we gathering them for a transition over here or to wash hands, we are getting them to sit down, and some of them need some boundaries and that's why sitting calms them. But if we had something like a circle or dot they can stand on. It's still a boundary

Step 3: According to educators, what are the potential solutions to reducing children's sitting time in childcare centres? (Table 4.3)

Solutions to reducing total and prolonged sitting in children at childcare were suggested by educators in the following themes: 3.1 childcare practice changes, 3.2 physical environment changes, 3.3 additional equipment, and 3.4 awareness.

3.1.1 Childcare practice changes

Educators suggested modifications to current routine activities that may reduce children's sitting time in childcare. They mentioned certain practices where sitting is not really required. For example, a song several educators use during their daily practices, is "look who is here now", which is often done sitting down, but could easily be changed to getting the child to stand up when they hear their name (3.1.1). Changing the order of activities within the childcare routine would be another possibility to break up prolonged sitting (3.1.2). Modifying the place where children have lunch was suggested as another option (3.1.3). During lunch, most centres have a bin in the middle of the table to place food scraps in. Educators suggested that instead of having the bin in the middle of the table it could be placed further away, meaning that children would need to stand up and walk to the bin (3.1.4). As children often sit for prolonged periods of time during mealtimes, educators reported they could possibly do a movement break after the meal (3.1.5). To break up sitting time during story time, educators all suggested that they could ask children to stand up and come over to the educator to turn the page (3.1.6).

3.1.2 Physical environment changes

Within the physical environment, educators identified several changes that could be easily implemented to reduce sitting time. The majority reported that moving the chairs away from the tables would be a potential solution to reduce sitting time (3.2.1), but highlighted that they still want to have the same experiences at the tables (3.2.2). When taking away chairs from some tables, educators mentioned that it was important to rotate the activities, because then different children would be targeted (3.2.3). In one childcare centre, educators reported that they had implemented this strategy after data on children's sitting time were collected during phase I of this study (3.2.4). Educators indicated that it was also important for them to consider where activities were located before mealtimes. In one centre where they had two outdoor spaces, children tended to move more and sit less when group time took place in the larger space, compared to the smaller space (3.2.5).

3.1.3 Equipment

Educators mentioned numerous types of equipment that could reduce sitting time among children in childcare. Having more easels was one suggestion, as these encourage children to stand when painting or drawing (3.3.1). Mini trampolines were suggested as another solution as this equipment does not take up a lot of space and it is a quick way for children to be energetically active (3.3.2). Children in childcare have the possibility of spending some time on electronic tablets and this is typically completed sitting down. The educators suggested that a standing table where children could use an electronic tablet would be one way to decrease time spent sitting (3.3.3). Lastly, educators identified that wall-mounted activities, such as puzzles or a water wall, would be another possible modification to reduce sitting time (3.3.4, 3.3.5).

3.1.4 Awareness

In addition to having practical solutions, educators highlighted that it may also be important for them to be more aware of the time children spent sitting while in childcare and developing habits to reflect on implementing the proposed changes to reduce sitting time (3.4.1, 3.4.2,). Likewise, educators also mentioned that the mind-set of children should be encouraged when implementing changes in the physical environment (3.4.3), as some children were not sure if they could still use a certain space when the equipment or furniture has changed. This would be better supported if parents were also more aware of why children need to break up their sitting time (3.4.4). Most educators agreed that the activities should be realistic and used consistently (3.4.5,). According to one educator, the key to implement the activities is to make it visual (putting up a sign in the room) for other educators (3.4.6).

Table 4. 3 Quotations from educators for step 3: Which solutions did the educators identify to reduce sitting time?

3.1	**Childcare practices changes**
3.1.1	Or with “look who is here now”, it is good to see Emily is here and they can stand up. Or just even standing up and then sitting down makes a difference. And that is easy to do. We sing it every day!
3.1.2	We reflected on that as well and we were doing that where they 10.30 they were doing indoor/outdoor in this room but now they come in for a bit of sitting, and then its news and then its free play inside, news, group in door outdoor and then lunch. We mixed it up a bit, it’s too much sitting sitting.
3.1.3	I mean mealtimes you’ve got no choice, legally they have to be you know they can choke. But we had a picnic, now that’s different, you have to reach right over to put something in the bin, you have to get right up to you know…they like that.
3.1.4	We could trial not have the bin on the table, but move the bin, so they have to walk to put the rubbish in the bin. Like a separate table with the bin.
3.1.5	Include energy breaks after meal times as meal times involve a long sitting period.
3.1.6	I remember when I was in pre-school, we had a big book and the teacher would let you come up and turn the page. You know, it’s not all of them, but if you sitting nicely you can come up and turn the page next
3.2	**Physical environment changes**
3.2.1	Simply moving the chairs away from the tables.
3.2.2	Well I guess what you said, we can do more things like not having the chairs at the tables, with experiences, because you still want those experiences set up. Like you still want to have things like drawing out.
3.2.3	Some children might always do creative arts. If you got chairs missing from the creative area it will benefit those children. But if you take chairs away from the puzzle area, then you will target different children.
3.2.4	The other thing we have got now is the train table. Instead of having it at the floor, they do that constantly, they are always standing at that table. They didn’t have that before when you did the study.
3.2.5	Even before lunch, we did like our group time in the big yard. And that changed so much on how they move, because there is so much more space.

3.3	**Equipment**
3.3.1	Yeah just rethinking, do we get a few more easels, because art can be, you tend to stand more when you are at an easel. It's one way of looking at it. It does encourage that. If you got an easel with two sides, it would encourage more.
3.3.2	I have suggested on getting mini trampolines, so then if you feel like there is a need to get rid of some energy we could use those. For like a sensory as well as energy. And it doesn't take up a lot of space and it is in the one spot. With some of the behaviours sometimes you know you are struggling with the height and behaviours, they need to be re-centred. It's an outlet.
3.3.3	I wonder with the iPad, because that's a time where they are sitting usually. We usually try to get them to stretch or do something after it. But if you had the table they can be standing at the height. And it is safe for the iPad as well.
3.3.4	Puzzle mounted at the wall by strings.
3.3.5	We are constructing a water wall with constructed water bottles.
3.4	**Awareness**
3.4.1	And that's just getting it in your mind, sometimes I walk past and experience oh maybe I should have put the chairs away too, because they got paint all over them all they have done is stood there with the chair behind them anyway. That is one thing we can get more in the habit of doing.
3.4.2	So, these are all ideas that we all had and all been trained in, it is just about rethinking and re-implementing and basically thinking a bit more why we are doing this.
3.4.3	I think it's about encouraging the children's mind-set, even though they are very young. Because when we did take the tables away first time they assumed the area was closed.
3.4.4	What I like to do is let the parents know and give them a reason why it is really good for children, do you have anything as far as research shows I know that some children need to centre, but is the way to centre them to give them some physical release and then they can centre and then they can focus, do you have anything that might explain that.
3.4.5	Remembering to implement and sustain the changes suggested.
3.4.6	For us I think it is about looking at how we would predominantly learn, a visual thing. Putting something up on the wall, remembering how to do this. And talking about it during staff meetings, so everybody is on board at doing similar things. Making sure the staff are doing what we ask them to do. And that is the biggest thing I think around this, it needs to become automatic without thinking about it all the time.

4.5 Discussion

The purpose of this qualitative study was to understand early childhood educators' perceptions of young children's sitting time in childcare, potential factors that contribute to high levels of sitting time, and possible modifications that could be made within childcare centres to promote less sitting among children. Thematic analysis of focus group data showed that most educators were surprised that children spent approximately 50% of their day sitting in childcare (Ellis et al., 2016). Educators generally agreed this could be reduced by identifying factors that contributed to high levels of sitting among children and developing potential solutions to reduce children's sitting. The factors included childcare practices, physical and natural environment, as well as parent and educator values. The potential solutions that educators identified included changes in childcare practice, the physical environment and equipment to reduce sitting time. To implement these changes, educators emphasised being more mindful about this through reminding educators and children, being consistent and providing information sessions with educators and parents. These findings could be used to inform the development of interventions to reduce sitting time in childcare.

The first important finding was that the majority of educators were surprised that children spent a large proportion of their time in childcare sitting; they believed that young children engaged in a lot of moving throughout the day. This finding is in line with other qualitative studies (De Decker et al., 2013; Määttä et al., 2016), where educators assumed that pre-schoolers engage in adequate physical activity behaviours during childcare. These educator perceptions do not correspond with recent research based on objective measurements, indicating that young children spend 40% to 80%

of their day at childcare in sedentary behaviour (Brown et al., 2009; Ellis et al., 2016). This could be due to a lack of awareness or knowledge of recent research, and not knowing the guidelines for young children's sedentary behaviour or physical activity. So, providing educators with information about the prevalence of young children's sitting time in childcare, as well as sedentary behaviour and physical activity guidelines might be important when developing interventions to reduce sitting time.

The second important finding that warrants discussion is the educators' perceptions of the factors that influence children's sitting time in childcare. In this study, educators mentioned that children mostly sat during group sessions, such as mealtimes and group times, which is consistent with findings from other studies (De Decker et al., 2013; Määttä et al., 2016). In addition, educators identified that the physical environment was a potential factor influencing children's sitting time. Moreover, educators reported that the weather and season might influence children's sitting time. Interestingly, studies by O'Connor and Temple (2005) and De Decker et al. (2013) somewhat support this finding; they noted that the weather had an important influence on lower physical activity levels in children at family daycare and childcare. Given the potential increase in children's sitting time due to bad weather conditions, it is important for childcare centres to provide creative solutions to counter the impact of these environmental limitations.

According to educators, parental and educator values also play an important role in the amount of time children spent sitting, as they both have a strong belief that children are required to learn to sit still to be ready to go to school. This finding is consistent with two studies where educators report that children need to sit down to be prepared for primary school (De Decker et al., 2013; Määttä et al., 2016). They furthermore reported that sitting assists in calming children, and that it is often used as a boundary. Additionally, their view was that children need to sit down to concentrate. However, Diamond & Lee (2011) reported that higher order cognitive processes such as executive functions, which are a better predictor of school readiness than IQ (Blair & Razza, 2007; Welsh, Nix, Blair, Bierman, & Nelson, 2010), could be improved through not requiring the children to sit still for long periods of time (Diamond & Lee, 2011). Therefore, educating parents and educators on the importance of providing children with different ways of learning that integrate movement and limit prolonged sitting might be necessary. Lastly, changes in the childcare practice, physical environment and the educator awareness were suggested as potential solutions to reduce sitting time in young children, a finding that is in line with De Decker et al. (2013). However, in the focus groups in the study of De Decker et al. (2013) not all topics were addressed that could potentially influence pre-schooler's sedentariness (e.g., presence of desks in the classroom, incorporating standing or light physical activity into otherwise sedentary lessons). Whereas in this study the educators suggested removing chairs or implementing a standing desk, which has been shown to decrease overall sedentariness in primary school children (Hinckson et al., 2013). Plus, a further benefit is that the tables in childcare are often an ideal height for a standing table, meaning that it will be simple to implement in all the childcare centres. Also, movement breaks after long periods of time sitting were suggested by the educators. Including breaks has been shown to be an effective option to increase physical activity levels in children (Katz et al., 2010). However, to our knowledge, only one study have examined the effects of activity breaks in pre-school children during childcare (Alhassan et al., 2016). This study did not see a significant change in total preschool-day (objectively measured) PA levels.

This is the first study in Australia to explore the educators' perceptions of the factors that influence children's sitting time in childcare centres and potential solutions to reduce this. Further strengths of the current study include the use of focus groups to explore childcare educators' ideas about realistic, practical, acceptable, and sustainable solutions that can be used in reducing sitting in their daily practice. Their proposed solutions express awareness of the need for healthy practices. Lastly, the semi-structured schedule allowed childcare educators to discuss themes and generate new solutions that the moderator had not thought of before the focus group. However, limitations include the use of focus groups where educators may have felt peer pressure to provide similar answers as their colleagues or "acceptable" responses to the facilitator. Furthermore, at the time no demographic descriptives were obtained from the educators, which is important information for interpreting the results.

This study confirms that engaging childcare educators in sharing their perceptions and ideas is an important first step to creating and implementing an intervention to reduce sitting time in young children. Furthermore, childcare educators should receive professional development on how to reduce sedentary behaviour and promote physical activity at childcare.

4.6 Conclusion

In conclusion, this qualitative study shows that childcare educators are unaware of the current levels of sitting time in young children at childcare. Educators identified the childcare practice physical environment and parental and educators' values as factors that could be modified to reduce young children's sitting time in childcare. These potential solutions should be evaluated to understand their effectiveness.

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Chapter 5

The acute effects of a 'reduced sitting pre-school day' on executive function and musculoskeletal health in pre-schoolers: a randomized cross-over study

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Note

Unfortunately due to technical issues I was unable to report on the Energy Expenditure outcomes for this study. Over the past three years, a considerable amount of time and effort went into trying to resolve the technical complications with the whole body calorimeter and to attempt to calculate the energy expenditure data of the 29 participants (Appendix H). In the end the data appeared not to be reliable to include in the paper submitted for publication.

5.1 Abstract

Pre-schoolers are spending a large part of their day at childcare sitting. The acute health and cognitive effects associated with prolonged sitting are not well understood in this age group. The purpose of this randomized cross-over study was to examine the acute effects of a reduced sitting day on cognitive development and musculoskeletal health in pre-schoolers. A sample of 29 children (54% boys; mean age (SD) = 4.7y) participated in a randomized cross-over trial. Each child completed two protocols which simulate half (2.5h) a day at childcare in random order; a typical pre-school day (50% sitting) and a reduced pre-school day (25% sitting) where most sitting activities were replaced with standing activities. Sitting, standing and stepping time was objectively assessed using an activPAL accelerometer. Cognitive development was evaluated using tablet-based executive function assessments (inhibition, working memory and shifting). Musculoskeletal health (flexibility and strength) were assessed using a hand-held dynamometer (HHD) and goniometer. Compared with the typical pre-school day, the reduced sitting day showed the following small effects for inhibition $P = 0.80$; effect size [Cohen's d] = 0.04; working memory $P = 0.94$; d=0.02; and shifting P=0.74; d=0.11. For musculoskeletal health no significant differences were reported. Positive small effect sizes were found for hip extension P=0.52; d=0.21, gastrocnemius P=0.42; d=0.25, hamstring length P=0.48; d=0.28 and stability P=0.48; d=0.28 after the reduced sitting day. This study suggests that replacing sitting time with standing is unlikely to result in acute changes in executive function and musculoskeletal health among pre-schoolers.

Key words: *Sedentary Behaviour, Childcare, Executive Function, Pre-school*

5.2 Introduction

Sedentary behaviour refers to waking activities characterized by an energy expenditure of ≤1.5 metabolic equivalents while in a sitting, reclining or lying posture (Tremblay et al., 2017), independent from physical activity behaviours of various intensities >1.5 METS (i.e., light- moderate- and vigorous intensity) (Salmon, Tremblay, Marshall, & Hume, 2011). Pre-schoolers appear to spend approximately 64% of their waking time sedentary (Andersen et al., 2017; Ellis et al., 2016; Hnatiuk, Salmon, Hinkley, Okely, & Trost, 2014; Ward, Vaughn, McWilliams, & Hales, 2010). Spending prolonged periods in sedentary behaviour appears to be negatively associated with health and developmental outcomes in children, particularly children who are obese (Cliff et al., 2014; Mitchell, Pate, Beets, & Nader, 2013; Saunders et al., 2013). To counteract these negative health outcomes, two experimental studies have shown improvements in cognition, reduced cardiometabolic rise and lower BMI z-scores from breaking-up prolonged sedentary time (Saunders et al. 2013b; Penning et al., 2017). Collectively, these studies suggest that reductions in sitting time are associated with positive health outcomes in children and adolescents. However, a recent systematic review (Poitras et al., 2017) indicate that the evidence on objectively measured sedentary time and health and development in pre-schoolers is scarce and inconsistent, and there is a need for experimental studies to provide causal evidence.

Most pre-schoolers in Australia, more than 80% of 3- and 4- year olds, spent at least a day a week at childcare (OECD - Organization for Economic Cooperation and Development, 2014). Therefore, interventions in childcare settings may be more generalizable to large proportions of the pre-school population. A study in 11 childcare settings in Australia showed that pre-schoolers spent approximately 50% of their childcare day sitting (Ellis et al., 2016) and that nearly half of the pre-schoolers did not meet the sedentary behaviour recommendation of sitting or standing still less than 30 minutes at a time (Institute of Medicine, 2011). As such, the childcare setting is essential in influencing children's sedentary habits (Ward et al., 2010). Childcare settings can be re-imagined and re-invented so children can be more active, healthier and more productive. However, there are no experimental studies which replicate a childcare day and examine the acute effects of reduced sitting time on health outcomes.

The effects of prolonged sitting time on cognitive outcomes have gained more interest (Voss, Carr, Clark, & Weng, 2014). In pre-schoolers the relationships of too much sitting on cognition are unclear (Poitras et al., 2017). A key developmental period for cognition is the early years, where higher-order cognitive control processes or also named executive functions (EF) develop rapidly (Howard & Melhuish, 2017). EF include three inter-related functions; inhibition (suppressing attention), cognitive flexibility (ability to shift mental sets), and working memory (activation of information via attention) (Howard & Melhuish, 2017). These EF are strong indicators of school readiness and a better predictor of academic achievement than IQ (Blair & Razza, 2007), and are linked to pre-schoolers psychosocial development and behaviour (Schoemaker, Mulder, Deković, & Matthys, 2013). Preliminary evidence implies that breaking up sedentary time may improve cognitive outcomes in children (Dornhecker, Blake, Benden, Zhao, Wendel, 2015). However, in young children there are no experimental studies that have tested the accute impact of reducing sitting time on EF in young children.

Standing has been encouraged as a substitute for sitting in adults (Buckley et al., 2015), as this would require work from the skeletal muscles for upright movement (Hamilton, Hamilton, & Zderic, 2007). However, this does not involve of movement and has potential negative health implications, such as lower limb discomfort (Antle & Côté, 2013). In young children the evidence on the impact of reducing sitting time by standing more on musculoskeletal health is scarce. One cross-sectional study among (n = 1512) pre-schoolers reported that sedentary time was negatively associated with bone stiffness. However, once adjusted for MVPA, the relationship was no longer significant (Herrmann et al., 2015). It is therefore important to examine the causal effects of decreasing total and prolonged sitting on children's musculoskeletal health.

Sitting time has furthermore been related with excess food intake and weight gain in children and youth (Chaput, Visby, Nyby, 2011; Tremblay, LeBlanc, Kho, 2011). Consequently, two experimental studies have reported on the compensatory effects of reducing sitting time, showing that children do not compensate for an acute bout of prolonged sitting by reducing food intake or increasing PA levels (Saunders et al., 2014; Penning et al., 2017). Yet, this has not been examined in young children.

An important limitation of this evolving evidence base is the absence of studies in children under 6 years of age (pre-schoolers), which are needed as sedentary behaviour has been shown to track at a moderate level from early childhood (birth to 5 years) into childhood (Jones, Hinkley, Okely, & Salmon, 2013). Therefore, this study aimed to examine the acute effects of a reduced sitting pre-school day on executive function and musculoskeletal health. This study also examined if there were any compensatory effects made by pre-school aged children on energy expenditure and energy intake as a result of a modified "sit less, stand and move more" pre-school day. Given the evidence, we hypothesised that the "sit less, stand and move more" pre-school day may lead to improved executive functions and musculoskeletal health.

5.3 Methods

5.3.1 Study design

This study used a within-subject randomized cross-over design. The trial was reported in accordance with the CONSORT statement (Moher et al., 2010) and was registered as a clinical trial with the Australian and New Zealand Clinical Trials Registry (ACTRN12614001028695). The study was approved by the University of Wollongong's Human Research Ethics Committee (HE13/406) (Appendix D)**.** Initially, Energy expenditure measured by the calorimeter room was the primary outcome in this study. Unfortunately due to technical malfunctions in the calorimeter room, it was not possible to analyse the raw energy expenditure data.

5.3.2 Participants

Participants were recruited from the Illawarra region of New South Wales (population 0.4M) via a university media release, university website and childcare newsletters between September 2014 and September 2015. Parents and guardians of interested participants were interviewed over the telephone to ascertain if their child was eligible for the study. Data collection occurred in September 2014 till February 2016. The order in which participants completed each condition were randomized by an independent person (data manager) using a computerised random number generator. Participants were excluded if they were: outside the predetermined age range (3-5 years), had disorders of mobility, which would affect their participation, or disorders that might alter their energy expenditure. Eligible participants' parents provided informed written parental consent.

5.3.3 Study protocol

Children and their families visited the calorimeter room three times (Figure 5.2). Visit 1 involved an initial familiarisation with the calorimeter room, to ensure the child was comfortable with completing the activity protocol (Appendix G) in the calorimeter room, and a discussion with parents and children to start the process of consent (Appendix E). After parental consent was provided, the child's height, weight, body fat percentage, BMI (in light clothing, without shoes) were measured using a stadiometer and a segmental body composition analyser (Tanita BC-418A Tanita Corporation Illinois, USA). Weight status was calculated using LMSGrowth (Medical Research Council, United Kingdom) and UK reference curves (Cole & Lobstein, 2012). Baseline musculoskeletal assessments and EF tests were also conducted. The child took home an information book which parents read to them several times to familiarise them with the study (Appendix F). Five to nine days after the initial assessments of EF and musculoskeletal assessments in visit 1, the second and third session was administered by the same examiners in the same location and using the same procedures as during the initial test session.

Visit 2 and 3 were randomized over two conditions, both lasting for 2.5 hours, either the typical pre-school day (50% of time spent sitting) or the reduced pre-school day (25% of time spent sitting). The length of sitting time in the 'typical' school day was informed by a previous study which reported that young children sat on average for 50% of a typical school day (Ellis et al., 2016). Furthermore, as descriptive data indicated that only 2% of pre-schoolers had a sitting bout of more than 20 min (Ellis et al., 2016), the longest sitting bout in the protocol was 20 minutes. Participants arrived between 7.30 and 8.00 a.m. where they were provided with a standardised breakfast after fasting overnight, this was standardised between condition by offering same amount on next visit. All participants were inside the calorimeter room for 2.5 hours; entering between 8:30 and 9:30 a.m. and exiting from 11:00 to 12:00. Before entering the calorimeter room, each participant was fitted with an activPAL (PAL Technologies, Ltd., Glasgow, UK) on their right upper thigh and the ActiGraph on the right waist. After 1.5hr in the calorimeter room a standard morning tea was consumed. During the typical protocol, participants spent 50% of their time in the calorimeter sitting, undertaking tasks that they normally would do as part of a typical day at pre-school, e.g drawing, music or reading. Non-sedentary behaviour activities included throwing the ball in the basket, dancing, playing mini-golf and bean bag throwing. After exiting the calorimeter room, the participant completed post-condition musculoskeletal and executive function tests in the same order at visit 2 and 3. The child also received lunch, which was weighed before and after the meal to measure energy intake. Visit 3 (modified pre-school day-25% of time spent sitting) was identical to visit 2 except that participants sat for 50% less time and replaced this with 50% more time spent in light-intensity activity (such as standing) (See Figure 5.1). Moderate to vigorous physical activity (MVPA) was kept consistent between the two conditions (approx. 15 minutes each). The modified pre-school day was based on the modifications suggested by early childhood education and care centre staff (e.g. height-adjustable standing desk and breaking up sitting with standing and stretching) (Ellis, Cliff, & Okely, 2017), and confirmed by the authors and a trained qualified childcare educator as developmentally appropriate. Parents were able to view their child in the calorimeter through a window and communicate with them via intercom if necessary. The child was constantly supervised by the first author and in contact with a trained qualified childcare educator, who progressed the child through the activities in the protocol.

Figure 5. 1 Pre-schooler in the “typical” and “reduced” pre-school day

5.3.4 Outcomes

Executive function

Executive function was measured using three iPad games; 1) inhibition ('Go/No-Go'), 2) visual-spatial working memory ('Mr Ant') and 3) task shifting ('Card Sorting') from the Early Years Toolbox (EYT, http://www.eytoolbox.com.au) (Howard & Melhuish, 2017). The Early Years Toolbox is a readily available and valid battery of iPad-based executive function, language, self-regulation, and social development measures that have been designed and psychometrically tested with pre-school aged children (Howard & Melhuish, 2017). Prior to commencing, participants were given instructions. All iPad apps had built-in auditory instructions so data collectors could ensure the participant understood the instructions, clarified where necessary and remained on task. In the Go/No Go test, children were required to tap the screen on "go" trials ("catch the fish") and not tap the screen on "no-go" trials (avoid catching sharks"). As the majority of stimuli were go trials (80% fish), this generated a prepotent tendency to respond, requiring pre-schoolers to inhibit this response on no-go trials (20% sharks). In Mr Ant, children saw a cartoon ant with 1 to 8 coloured stickers on his body. Children were required to remember the placement of these stickers and, after a delay, indicate these spatial locations. The task continues until the earlier of completion (at Level 8, with eight spatial locations to remember) or failure on all three trials at the same level of difficulty. With the dimensional Change Card Sorting Task (shifting) – children were required to sort cards by one dimension (e.g., colour) before switching to a new sorting dimension (e.g., shape). If completed successfully, children were required to flexibly switch between colour and shape sorting rules on the basis of the presence/absence of a border around the stimulus. If the participant correctly sorts at least five of the six pre and postswitch stimuli, they proceed to a border phase of the task. In this phase, children are required to sort by color if the card has a black border or sort by shape if the card has no black border. After a demonstration trial and two practice trials, this sorting rule is reiterated prior to presenting the six stimuli for sorting (consisting of three bordered stimuli and three nonbordered stimuli). Each measure was designed to be brief (≤5 min, including instruction and practice), engaging, and leverage the affordances of technology (e.g., animation, audio, and accurate capture of responses and response timings). Together, these tasks took ~20 minutes to complete (in some cases shorter, due to stop rules) (Howard & Melhuish, 2017).

Musculoskeletal health

The assessment of these outcomes were selected by physiotherapists from Wollongong Hospital as being the most appropriate to examine their potential relationship to sitting time in pre-schoolers. Musculoskeletal health was assessed by two examiners using seven different tests. One examiner performed the test and the other examiner double-checked the score and wrote this down. First, the preferred or dominant extremity was determined by the foot used to kick a ball for two out of three trials (Gajdosik, 2005). The first two tests measured the strength of knee and hip extension and used standardized procedures (Macfarlane, Larson, & Stiller, 2008).

The child was seated on a height adjustable plinth for the first five tests. *Knee extensor* muscle strength was measured by positioning the child seated on the plinth with their hip and knee flexed and feet off the floor. A hand held dynamometer (HHD) (Nicholas manual muscle tester, model 01160, Lafayette Instrument Co., Lafayette, IN) was placed on the anterior surface of the ankle proximal to malleoli on the dominant leg. The HHD measures muscle strength from 0.0 up to 199.9kg, with a precision of ±0.1 kg. HHD standardised procedures is fair to excellent reliability in 3 to 4 year olds (Gajdosik, 2005). The examiner sat in front of the child stabilising the thigh in neutral above knee. The child was asked to try and straighten their knee and push out as far as they could for five seconds. This was measured three times with one minute rest between attempts (Macfarlane et al., 2008). *Hip extensor* muscle strength was measured by positioning the child lying to the side with their hips and knees flexed at 45 degrees. The HHD was placed on the posterior surface of the dominant thigh proximal to femoral condyles. The child was asked to bring their leg back and push as hard as they could for five seconds. This was done three times with one minute rest in between attempts (Macfarlane *et al.* 2008).

Hamstring length was measured using the popliteal angle hamstring muscle test (Czaprowski et al., 2013). The child was positioned supine on the plinth, the examiner brought the thigh to 90 degrees (whilst keeping the opposite leg straight). The examiner then gradually straightened the child's knee while ensuring the foot was comfortably plantarflexed and the thigh kept vertical. A goniometer was used to measure the angle between vertical and the lateral malleolus. The average degrees for children aged 4 years is 24 degrees. Less than 50 degrees is normal and more than 50 degrees is abnormal (Gajdosik, 2005). *Gastrocnemius length* was measured by positioning the child prone on a plinth, with their feet over the edge and their knees extended. The middle of the goniometer was placed on the child's lateral malleolus, and the arms of the goniometer on the head of the 5th metatarsal and the head of the fibula. The examiner was positioned behind the child, stabilising the iliac crest. The child was relaxed while the examiner stretched the foot (gently moved the ankle until the end of range). *Soleus length* was measured with the child in the same position except with their knees at 90 degrees. The goniometer was placed in the same location. The child was relaxed while the examiner stretched the foot (gently moved the ankle until the end of range).

Balance was measured by the child standing with one foot in directly in front of the other in a heel to toe position (tandem stance) and keeping as still as they could. The best measurement out of three trials was recorded. The test was stopped if either foot left the floor and/or upper extremity support was used. Balance was also assessed by timing the child *standing on one leg*. The child stood on the dominant leg only with their arms by their side, knees slightly apart. The examiner was in front of child to monitor foot position and position of non-supporting leg. The child was asked to stand on one foot for as long as they could without holding on and without their knees touching. The time was kept by the examiner. This test was terminated if either foot left the floor, the non supporting leg touched the support leg and/or upper extremity support was utilised (Franjoine, Darr, Held, Kott, & Young, 2010). The assessment and interpretation of these outcomes were overseen by paediatric physiotherapists from the local Hospital, who had selected these measures as being the most appropriate to examine the potential acute effects of reducing sitting time in young children.

Compensation data

Energy expenditure

As there is a possibility that children may compensate for sitting less and engaging in more light-intensity PA by being less active afterwards, participants were asked to wear a SenseWear mini arm band (Body Media) for 48 hours immediately following Visit 2 and 3 to assess energy expenditure. The armband was worn on the upper arm and has been validated in children (van Loo et al., 2017). The arm band measures daily energy expenditure (kcal/d) and measured active energy expenditure (kcal/d). The armband was taken off during sleep times and during periods of water submersion (i.e., swimming, bathing). Parents were asked to fill in a one-page log that indicates when the accelerometer was worn or not worn (eg. removed for bathing).

Energy intake

To measure if participants compensated for less sitting by increasing their energy intake, participants received an *ad libitum* lunch at the same time after each condition. Lunch consisted of a variety of foods, such as white or wholemeal bread, noodles or spaghetti, differing in macronutrient composition which their parents selected from a written menu at baseline. The participants were provided with additional servings on request. The participants were given 45 min for consuming this meal. All food were weighed to the nearest 0.1 g before and after consumption. Energy and macronutrient intakes were calculated in Foodworks (Version 7, Xyris Pty Ltd, Australia) professional nutritional analyses package.

Activity monitors

Before entering the calorimeter on Visits 2 and 3, participants were fitted with an activPAL (PAL Technologies, Ltd., Glasgow, UK) on their right leg and an ActiGraph GT9X Link (Actigraph, Pensacola, FL, USA) on the right waist. The activPAL measured total time spent sitting, standing and stepping. The activPAL has been shown to be a valid measurement tool for discriminating between different postures in young children (Janssen et al., 2014). The activPAL was placed on participants' upper thigh (Davies et al., 2012; Janssen et al., 2014) using tape. On and off times were recorded by the first author. Data from activPAL was downloaded to a computer using activPAL software (v7.2.32) and then exported to Microsoft Excel 2013 format file. A customised Excel macro was used to calculate total sitting, standing and stepping times from event files. The event file shows the time spent in each posture (‘0’ as sedentary, ‘1’ as standing and ‘2’ as stepping). Every change from code 0 to code 1 or 2 was considered as transition/break from sitting to standing position. Times before entering the room and departure were manually removed from the total minutes monitored. Sitting breaks and bouts were determined from activPAL outputs. Mean breaks per hour in sitting were calculated as the total sum of the number of all sitting bouts (Dowd, Harrington, Bourke, Nelson, & Donnelly, 2012). Bouts of sitting were categorized as: < 1 min, 1- 9 min, 10–19 min and > 20 min (Carson, Stone, & Faulkner, 2014). Moderate to Vigorous Physical Acitivity (MVPA) data was derived from the ActiGraph output. The ActiGraph has established acceptability, validity and reliability in pre-school children (Cliff, Reilly, & Okely, 2009). Accelerometry data were downloaded as 15 second epochs (Cliff et al., 2009), and MVPA was defined using ActiGraph cut-points defined by Pate (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006).

5.3.5 Analyses

Sample size

Based on the average weight of a child aged 3-5 (20.6kg) and EE values for sedentary and light-intensity PA from our previous whole room calorimeter study in this age group, a sample size of 30 participants would provide 85% power to detect a difference in EE of 13kcal (with a SD of 20kcals and a within subject correlation of 0.3 between a typical and modified half-day at pre-school).

Statistical analysis

Analysis were performed in STATA (version 13, StataCorp LP) and SPSS (version 21, IBM Corporation). Descriptive statistics were calculated using means and standard deviations for continuous variables and frequencies and percentages for categorical variables. Analysis of the primary and secondary outcomes were conducted using linear mixed models in STATA 13.1. The mixed model contained a random effect for time (condition) nested within subject, which was adjusted for baseline values. Analyses were performed on intention to treat basis, and participants were included in the analyses if they had data for at least one condition. Statistical significance was set at $P<0.05$. Standardized effect sizes were calculated to demonstrate effects. Effect sizes of approximately 0.2, 0.5 and 0.8 are considered small, medium and large, respectively (Cohen, 1988). Paired samples t-tests were performed on the SenseWear Mini armband data and energy intake following both conditions.

5.4 Results

Of the 30 eligible participants, 29 participants (mean age 4.7± 0.5, 15 boys and 14 girls; Table 1) met the inclusion criteria and were included in the analyses. One participant discontinued with the study after the familiarisation visit (Figure 5.2). Protocol compliance was measured by direct observation and written records. Four participants deviated from the protocol due to either needing to go to the toilet or not wanting to sit or stand to do the activity. In response to this, additional time was added or sitting/standing time was added or replaced elsewhere in the protocol.

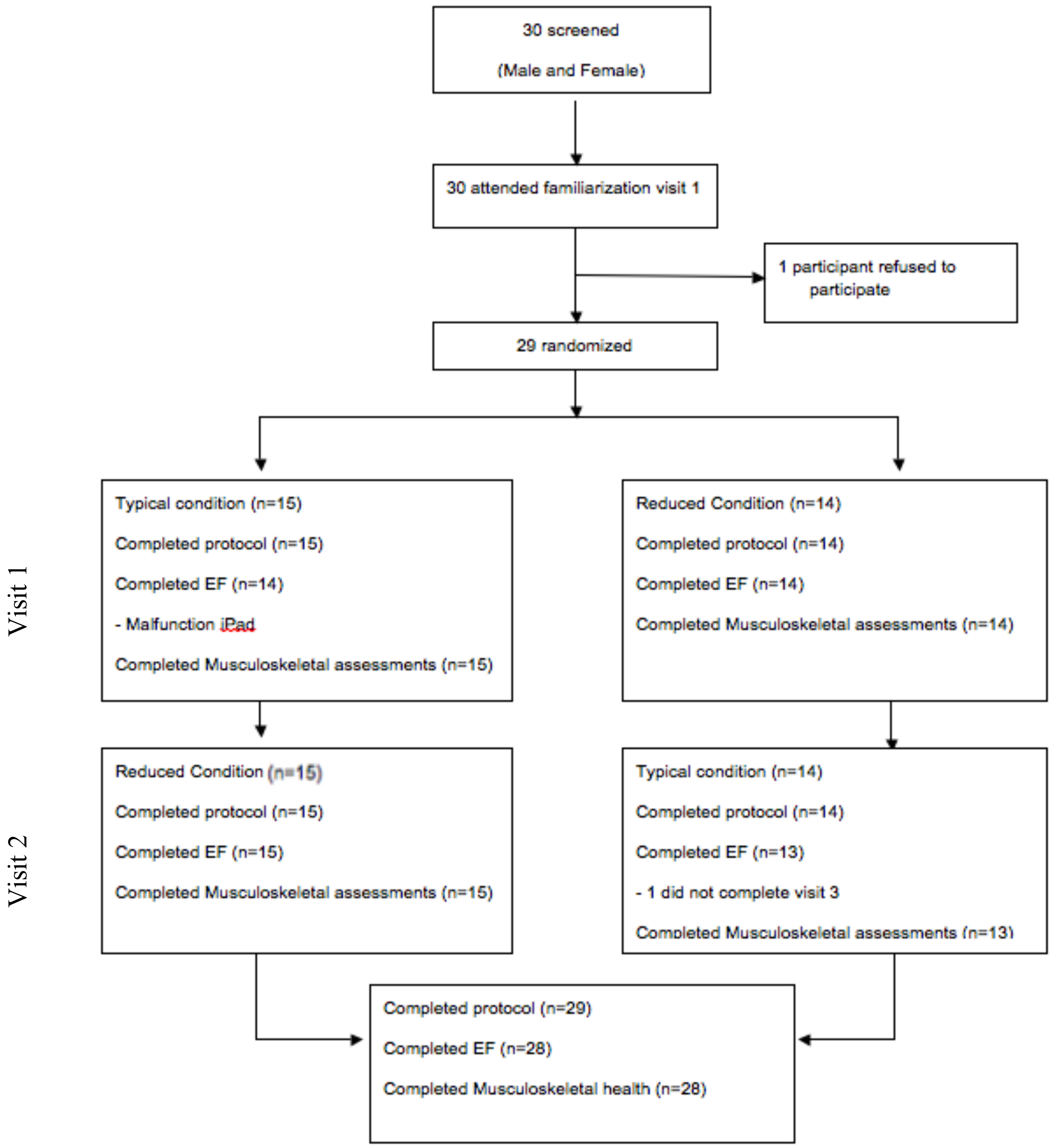

Figure 5. 2 Flow diagram of participants through study

Table 5. 1 Characteristics of study participants, mean ± SD

	All (29)	Male (15)	Female (14)
Age (years)	4.7 ± 0.5	4.9 ± 0.5	4.6 ± 0.5
Height (cm)	107.3 ± 6.1	109.8 ± 6.1	104.7 ± 5.2
Weight (kg)	18.2 ± 2.7	19.3 ± 2.8	16.9 ±2.1
BMI (kg/m^2)	15.7 ± 1.1	15.9 ± 1.3	15.5 ± 0.9
Body fat (%)	20.1 ± 2.3	19.2 ± 2.4	21.0 ± 1.8
Fat Free Mass	14.5 ± 2.2	15.4 ± 2.2	13.5 ± 1.7
Overweight/obese (%)	3 (10)	2 (13)	1 (7)

The amount of time spent sitting, standing and stepping accumulated during each condition (either typical or reduced) is reported in Table 5.2. As required, sitting time was 50% lower in the ‘reduced’ condition than the ‘typical’ condition (74.48 to 37.78 minutes) (P<0.0001), and standing (53.74 vs 84.52 minutes) and stepping (28.59 vs 21.44 minutes) time was significantly higher in the ‘reduced’ condition than the ‘typical’ condition (P<0.0001). As anticipated, MVPA was not significantly different between the two conditions (P=0.96).

Table 5. 2 Sitting, standing, stepping time and MVPA in the typical and reduced condition,

	Reduced	Typical	P value
Sit minutes	37.78 ± 5.65	74.48 ± 8.03	<0.0001
Stand minutes	84.52 ± 8.76	53.74 ± 8.94	<0.0001
Step minutes	28.59 ± 6.99	21.44 ± 6.07	<0.0001
MVPA minutes	15.03 ± 7.78	14.94 ± 6.80	0.96

mean ± SD

Executive function

The differences between average executive function scores (mean, SE) for each condition are reported in Table 5.3. Effect sizes for inhibition [d = 0.04], working memory [d=0.02] and shifting [d=0.11] were all small. The differences between conditions were not statistically significant.

Musculoskeletal health

The scores for the musculoskeletal health outcomes for each condition are shown in Table 5.3. None of the differences between conditions were statistically significant. The differences between conditions for the hip extension force (kg), hamstring flexibility (degrees), gastrocnemius length (degrees) and the amount of time balancing on one leg (sec) did show a small effect size [d=0.21, d=0.25, d=0.28, d=0.28] in the hypothesized direction.

Table 5. 3 Measures of Executive Function and Musculoskeletal health outcomes in the typical and reduced condition, mean ± SE

	Baseline	Reduced[a]	Typical[a]	Difference (reduced-typical) CI	P-value	Effect size[b]
Inhibition	0.73 ± 0.19	0.75 ± 0.04	0.74 ± 0.03	-.01 (-.10, 0.08)	0.80	0.04
Working memory	2.24 ± 0.87	2.19 ± 0.21	2.17 ± 0.19	-.02 (-.59, 0.55)	0.94	0.02
Shifting	6.86 ± 3.80	6.76 ± 0.80	7.15 ± 0.84	.39 (2.72, -1.94,)	0.74	0.11
Knee extension (kg)	4.94 ±1.51	5.05 ± 0.29	4.92 ± 0.24	.13 (-.89, .63)	0.73	0.07
Hip extension (kg)	4.78 ± 1.70	4.54 ± 0.33	4.26 ± 0.30	-.29 (-.60, 1.17)	0.52	0.21
Hamstring length (degrees)	22.29 ± 9.71	15.44 ± 2.11	17.47 ± 1.93	2.04 (-3.70, 7.78)	0.48	0.25
Soleus length (degrees)	94.64 ± 9.54	96.79 ± 1.55	97.09 ± 1.97	.30 (4.74, 5.34)	0.91	0.04
Gastrocnemius length (degrees)	86.21 ± 8.69	90.73 ± 1.45	89.25 ± 1.09	-1.49 (-5.132, 2.16)	0.42	0.28
Balance one foot in front (seconds)	21.50 ± 9.43	20.69 ± 1.74	19.04 ± 1.55	-1.65 (-6.34, 3.03)	0.48	0.13
Balance one leg (seconds)	9.61 ± 4.38	9.57 ± 1.16	8.75 ± 1.04	-1.00, (4.12, -2.12)	0.52	0.28

[a] Adjusted for baseline measures.
[b] Effect sizes were calculated on complete cases only for the differences between mean effects

Monitoring of energy intake and expenditure

The mean energy intake and energy expenditure from the participants are shown in Table 5.4. Whilst undergoing the protocol the mean energy intake was 798.34 kJ ± 389.84 kJ in the reduced condition and 759.86 kJ ± 322.08 kJ in the typical condition. During the lunch after the condition, no differences in energy intake between the typical (1004.83 kJ ± 501.00 kJ) and reduced conditions (1044.75 kJ ± 428.94 kJ) were found (P=0.55), indicating that there was no compensation. In the 48-h period following the protocols, there was no difference in total energy expenditure between the 'reduced' (M = 5695.46 kJ ± 1606.05 kJ) and 'typical sitting' pre-school day (M = 5766.12 kJ ± 2307.07 kJ) (P=0.95), indicating that there was no compensation.

Table 5. 4 Compensation outcomes from SenseWear and Energy intake in/after typical and reduced condition, mean ± SD

	Reduced	**Typical**	**P value**
Food intake Breakfast (kJ)	746.71 ± 363.39	732.28 ± 429.09	0.76
Food intake Morning tea (kJ)	798.34 ± 389.84	759.86 ± 322.08	0.44
Energy intake lunch (kJ)	1044.75 ± 428.94	1004.83 ± 501.00	0.55
SenseWear EE (kJ)	5695.46 ± 1606.05	5766.12 ± 2307.07	0.95

5.5 Discussion

This is the first study to examine the acute effects of reducing sitting time on executive function and musculoskeletal outcomes in young children during a simulated "typical" and "reduced" pre-school day. Several musculoskeletal health outcomes showed some favourable improvement with small effect sizes for hip extensor strength, hamstring and gastrocnemius flexibility. There were no differences for executive function scores. Furthermore, no differences were seen in energy expenditure compensation data, as hypothesized.

There is a growing interest in the effect of prolonged sitting time on cognition (Voss, Carr, Clark, & Weng, 2014). There are plausible mechanisms through which changes in sitting time might negatively affect EF (Voss et al., 2014). Evidence suggests this might be due to less efficient glucose metabolism, reduced insulin sensitivity and insulin resistance (Voss et al., 2014). While there are no other experimental studies evaluating the effects of reduced sitting time on executive function in pre-schoolers, there has been one randomized cross-over trial investigating effects of reducing sitting time on cognitive functioning in older children and adolescents (Penning et al., 2017). Likewise, Penning et al. (2017) reported medium effect sizes for cognition resulting from a decline in mental attention capacity after the typical school day and an increase after the reduced sitting day in 18 adolescents. These findings are in contrast with the outcomes of the current study. There are several factors which could explain the discrepancy between the current findings in pre-schoolers and those observed in older children. Firstly, the shorter duration that pre-schoolers spent in the calorimeter room compared to the adolescents in the study of Penning et al. (2017). The differences in sitting time in the current study might have not been large enough to detect any differences. In the study by Penning et al. (2017), adolescents spent 6 hours of their time in the calorimeter room and sitting time was reduced from 240 to 117 minutes of sitting, compared to the current study, 75 to 35 minutes of sitting. An explanation of not reducing sitting time more than 50% is because we want it to be realistic and able to translate this to the "real world". The second factor, could be a ceiling effect for executive function, as the average baseline scores were higher than the norm for this age group (Howard & Melhuish, 2017), providing little room for improvement. There is a dearth of evidence investigating the effect of sedentary behaviour on executive function in young children (Poitras et al., 2017). Additional experimental studies with longer activity protocols may be needed to evaluate the acute effect of reducing sitting time in young children.

Recent findings indicate that reducing sedentary time produces positive academic outcomes in primary school children in classrooms with stand-biased desks (Garcia, Huang, Trowbridge, Weltman, & Sirard, 2016). Garcia and colleagues (2016) examined the effect of stable and dynamic furniture on PA and learning in children aged 8 years. Movement was greater in the dynamic condition compared to the stable furniture condition. In the current study, the traditional desk was replaced with a height adjustable standing desk to replace sitting activities with standing (e.g., reading, writing and drawing). The pre-schoolers adapted to the new situation and reduced their sitting time and increased standing and stepping time. It is important that strategies for breaking up sitting time in the childcare setting are both feasible and effective in improving other health outcomes. Future studies should compare the long-term effects of traditional and dynamic furniture on health and executive function in childcare centres and other settings. It is therefore possible that simple adjustments to the childcare setting and outdoor environment can have acute effects on executive function in young people.

In addition to EF, musculoskeletal health in young children have shown to not be negatively affected by standing more in young children in a "reduced sitting pre-school day". Small positive effects in several tests have been reported. Mechanisms underlying the small improvements in hip extensor strength and balance after the reduced sitting condition may be due to the increased opportunities for muscle contraction provided from extra standing tasks. In adults, it has been shown that when a person engages in sedentary behaviour, the work by the large skeletal muscles required for upright movement no longer occurs. Infrequently interrupting sedentary behaviour would result in the loss of opportunities for potentially thousands of muscular contractions throughout the day (Hamilton et al., 2007). As such, it is possible that providing additional non-sedentary tasks for children may result in more opportunities for muscle contraction to positively effect the child's muscle strength and balance. The reason no significant changes were seen for hip and knee extensor strength may be due to pre-schoolers not being able to produce the maximal force during the assessments. Bäckman et al. (1989) described that children between the ages of 3.5 and five years have difficulty producing muscle actions about the hip (i.e., extension, flexion, and abduction) when compared to older school-age children. However, in this study, the muscle strength produced by this group of children was the same as normal values (Bäckman et al., 1989; Gajdosik, 2005). Other explanations could be that the child was not motivated enough or lost attention or that the duration of time between assessments was not long enough to detect changes in muscle strength. Overall, the current study shows that the standing desk and breaks in the routine not impair musculoskeletal health and children may have more varied postures in the "reduced pre-school day".

A possible reason for the small effect size in the hypothesized direction for the gastrocnemius length may be due to the greater amount of time spent standing and moving around in the reduced sitting day. As gastrocnemius is kept in a lengthened position when standing compared to sitting, sitting tasks could contribute more to gastrocnemius muscle shortening.

No compensatory effects on energy expenditure or energy intake were detected during the 48-h period after the two conditions. This is consistent with other studies of compensatory reductions in energy expenditure in older children and adolescents (Penning et al., 2017; Saunders et al., 2013). Saunders and colleagues (2014) found that children and adolescents did not compensate in the 24-h post experiment by increasing food intake or PA levels when sedentary behaviour was reduced or interrupted. Likewise, Penning and colleagues (2017) showed that reducing sitting time by approximately 50% did not result in a compensatory reduction in energy expenditure and increase in energy intake among adolescents in the 48-h period post intervention. These findings highlight that there is no immediate compensation of reducing sitting time by either decreasing energy expenditure or increasing energy intake. Therefore, modifications which increase standing and stepping and decrease sedentary behaviour might contribute to creating negative energy balance that might have important public health implications such as contributing to obesity prevention in early childhood.

The current study has some strengths and limitations. The design of this study is a strength in terms of ecological validity (Saunders et al., 2013) as this is the first randomized cross-over trial examining the acute effects of reducing pre-schoolers sitting time in a lab-based replicated childcare setting. Second, the standardized meals used in the present study were similar to what children would eat usually, increasing the ecological validity of the study. The study findings may be limited by the duration of the conditions, limiting the dose of exposure and potentially the effect on outcomes. In a similar study, adolescents stayed in the calorimeter room for 6 hours, compared to the 2.5 h in the current study. However, after piloting in this age group, 2.5 hr was the maximum that pre-school children could follow the protocol, as children arrived an hour before (breakfast) and stayed an hour after (executive function games, musculoskeletal health tests and lunch). Third, all pre-schoolers in the present study were healthy at baseline, and most had a healthy weight. Thus, it is uncertain whether comparable outcomes would be observed among a population of overweight or obese pre-schoolers or with children having lower EF and musculoskeletal health values. Fourth, the primary outcome of this study, energy expenditure, was unable to be analysed due to technical problems with the calorimeter room. However, the other outcomes, EF, musculoskeletal health and compensatory changes in pre-schoolers still add to the evidence-base in the area of sedentary behaviour and health in pre-schoolers. And lasty, the use of the SenseWear armband in pre-schoolers. At present, there is no feasible, accurate and relatively inexpensive measure to assess free-living energy expenditure in young children. Doubly labeled water is accurate, but very expensive and was beyond the scope of this study. Therefore, the SenseWear armband was considered the most appropriate alternative measure for assessing free-living energy expenditure in young children. Validation studies do suggest that the updated algorithms for this device that were used in our study may underestimate children's energy expenditure, particularly during higher intensity activities (van Loo et al., 2017). However, it should be noted that our study was a randomised cross-over trial with participants acting as their own control, therefore if there were errors in the SenseWear data these were likely to be the same for both conditions, cancelling each other out, and providing an appropriate estimate of the treatment effect (i.e., the difference between conditions).

5.6 Conclusion

This study is the first to explore acute differences in executive function and musculoskeletal health outcomes in pre-schoolers when comparing typical and reduced sitting time during a pre-school day. The findings suggest that replacing sitting time with standing is unlikely to result in changes in executive function and musculoskeletal health over an acute period of time (2.5h) among pre-schoolers. Musculoskeletal health changes might become larger over a full day or week. Furthermore, the findings showed that pre-schoolers do not compensate after a “typical sitting day” by increasing their energy expenditure or decreasing their energy intake, suggesting that a “reduced sitting day” might contribute to creating a negative energy balance. Modifying the childcare environment and routine to encourage breaking-up and reducing sitting time could promote a healthier energy balance in pre-schoolers. Future randomized controlled trial studies should further explore the effects of reducing sitting time on health outcomes and energy balance in pre-schoolers. Therefore, modifications which increase standing and stepping and decrease sedentary behaviour might contribute to creating negative energy balance that might have important public health implications such as contributing to child obesity prevention.

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Chapter 6

Feasibility, acceptability, and potential efficacy of a childcare-based intervention to reduce sitting time among pre-schoolers: a pilot randomized controlled trial

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6.1 Abstract

The aim of this study was to test the feasibility, acceptability and potential efficacy of a childcare-based intervention to reduce total and prolonged sitting time in pre-schoolers. Four centres and 115 pre-schoolers (44 % boys; 4.1y) participated in a 3-month, 2-arm pilot cluster randomized controlled trial. Feasibility, fidelity and acceptability were assessed through observations and semi-structured interviews. Sitting time, and breaks and bouts of sitting during childcare were assessed using an activPAL accelerometer over a one-week period at pre- and post-test (12wks). EF (inhibition, working memory and shifting) was assessed using the Early Years Toolbox. Intervention fidelity was high for both intervention centres (77 % vs 70 %) and educators reacted positively to the intervention. Proportion of sitting time per day reduced significantly at post-test in both intervention (-5.3%/day,[2.13, 8.50]) and control centres (-6.45 %,[4.20, 8.71]), resulting in a non- significant between-group difference ($p = 0.51$[2.4, 4.9]). EF scores did not significantly differ between groups ($p > 0.05$). Modifications to the childcare environment to reducing sitting, particularly the standing workstations, were feasible and acceptable to educators and children. No differences in sitting time between groups were seen; additional changes and longer-term trials are needed to reduce sitting time in pre-schoolers.

Keywords: *Sedentary behaviour, young child, executive function, self-control*

6.2 Introduction

Sedentary behaviour refers to all waking activities characterized by an energy expenditure of ≤1.5 metabolic equivalents while in a sitting, reclining or lying posture (Tremblay, 2017). High levels of prolonged sedentary behaviour are negatively associated with health and developmental outcomes in children (Cliff et al., 2014; Mitchell, Pate, Beets, & Nader, 2013; Saunders et al., 2013), particularly children who are obese, which is 41 million children under the age of 5 worldwide (WHO, 2016). Pre-schoolers (3 to 5 years) spend the majority of their day in sedentary behaviour, predominantly sitting (Ellis et al., 2016; Hnatiuk, Salmon, Hinkley, Okely, & Trost, 2014), which tracks from early childhood (birth to 5 years) through to adulthood (Jones, Kelly, Cliff, Batterham, & Okely, 2015). Reducing prolonged sitting in young children may be important for the prevention of diseases resulting from prolonged sedentary behaviour.

In adults, reducing and breaking-up sitting time with standing and moving has been shown to be beneficial for cardio-metabolic health (Dunstan et al., 2012). This may also affect cognition, as spending prolonged periods of time in sedentary behaviour might be a risk factor for cognitive decline via poor glycemic control (Wheeler et al., 2017). By breaking up prolonged sitting, the glucose uptake in skeletal muscles is expected to increase (Bergouinan et al., 2016). In school-aged children the cognitive consequences of too much sitting are unclear, however there are plausible mechanisms for sedentary behaviour affecting cognition (Voss, Carr, Clark, & Weng, 2014; Wheeler et al., 2017). A key developmental period for cognition is the early years, where executive functions (EF) develop rapidly. EF include inhibition, cognitive flexibility, and working memory. These are strong indicators of school readiness and a better predictor of academic achievement than IQ (Blair & Razza, 2007). Currently, there are no experimental studies testing the impact of reducing sitting on EF in young children. It is therefore important to examine the effects of decreasing total and prolonged sitting and increasing light physical activity on children's physical health and cognition.

A large proportion (80%) of pre-schoolers spend at least one day a week at childcare (OECD – Organization for Economic Cooperation and Development 2014), and have been shown to spend approximately 50% of their time at childcare sitting (Carson, Salmon, Crawford, Hinkley, & Hesketh, 2016; Ellis et al., 2016). To promote reductions in sitting time in childcare, the Institute of Medicine developed a recommendation for childcare providers stating that young children should be allowed to move freely and sitting or standing still should be limited to 30 minutes at a time (Institute of Medicine, 2011). However, Chapter 3 shows that nearly 50% of pre-schoolers do not meet this recommendation while at childcare (Ellis et al., 2016). This highlights that the childcare setting might be an appropriate environment in which to intervene. Interventions in these settings should work with educators to identify approaches that are feasible and acceptable (Ellis et al., 2018). The aim of this pilot cluster randomized controlled trial was to investigate the feasibility, acceptability and potential efficacy of a childcare-based intervention to reduce sitting time among pre-schoolers, and to assess whether a reduction in sitting time has an effect on EF.

6.3 Methods

6.3.1 Design

The Standing Pre-schools Study (Ellis et al., 2016) was a 3 month, 2-arm pilot cluster randomized controlled trial (RCT) involving four childcare centres in Wollongong, Australia (0.3M). The reporting of this trial follows the CONSORT statement recommendations (Moher et al., 2012). This study received approval by the Human Research Ethics Committee at the

University of Wollongong (HE16/023) (Appendix I). The trial was registered with the Australian New Zealand Clinical Trials Registry (ACTRN12616000341426).

6.3.2 Setting and recruitment

Pre-schoolers were recruited at childcare centres in April 2016. The recruitment target was four centres and 120 children aged three to five years. Recruitment was conducted through a face-to-face conversation a week before data collection at the childcare centre by handing parents or guardians an information sheet and consent form and explaining the study briefly (Appendix J). Parents or guardians provided informed written consent for their child to participate. Educators were also provided with an information sheet and consent form (Appendix K). These centres were randomized following consent and baseline measurements (LaRowe et al., 2016), to either intervention ("Stand more-Sit less" environment) or control ("Typical" environment) by a data manager external to the project using the biased-coin method. Post-test assessments occurred 12 weeks after the start of the intervention (November, 2016) (Figure 6.1).

6.3.3 Participants

Children were eligible to participate if they were three to five years at baseline. Exclusion criteria included diagnosis of a condition that may affect mobility or behaviour (e.g., Autism Spectrum Disorder).

6.3.4 Intervention

The intervention was designed in response to formative research shown in Chapter 4 (Ellis et al., 2018). The development of the intervention was completed using the Intervention Mapping process outlined by Robinson and colleagues (Cornelius et al., 2014). The intervention strategy included measures to reduce or break-up total and prolonged sitting time (>20 min). Five key intervention approaches were used (Table 6.1). Two standing tables were provided to each intervention ECEC centre (Figure 6.2). The primary author delivered a training session and information package (Appendix L) to all educators in the intervention centres. The information package included strategies, which educators identified in the formative research as being feasible and acceptable, on how to modify certain activities with the focus on reducing sitting and promoting standing and movement during a typical childcare day.

Table 6. 1 Activities to reduce sitting time in pre-schoolers

Activities	Description
Component 1: Height-adjustable standing table/easel	Replace two normal tables with standing tables. If more tables, remove some of the chairs away, so that the children can be standing. To use inside (or outside), when children are drawing, painting, building blocks etc. This can be during group time, table time or free play. Educators should encourage children to use the standing table by making these attractive by putting the play equipment on the table.
Component 2: Movement breaks	The childcare services are given a USB with more than 50 age-appropriate music tracks. One to 2 minutes "stand up" music based physical activities. Educators should try to facilitate these at least once a day. They can use it as a tool to get the children together, before transition starts or before or after lunchtime. These breaks are designed to require minimal equipment adaptable to all spaces (indoors and outdoors) and enthusiastic educators as role models.
Component 3: Active story time	Active story time should be facilitated at least twice a week. Different examples of stories have been given to the educators in which they could try to make these more active by for example asking the children to act out like an animal that is mentioned in the story. Or jump when you hear your name.
Component 4: Meal times	Replace the bin, so children will have to stand up to throw their food scraps away. Get children to stand up to get their water. If possible, get children to stand up while having their morning or afternoon tea.
Component 5: Nap time	Have children do quiet activities at standing desk if they do not want to nap or rest.

The intervention was guided by the Social Cognitive Theory (SCT) and focused on the four key processes for learning and adapting new behaviours: attention, retention, production, and motivation (Bandura, 2001). These four processes, along with specific constructs from each of the three (personal, behavioural, environmental) levels of SCT, were embedded in the theoretical and practical components of the intervention (Table 6.2).

Table 6. 2 Intervention strategies and activities and corresponding principles of Social Cognitive Theory

Activities and strategies	Description	Principle of Social Cognitive Theory
Professional development for the Educators	Educators will attend three 1-hour training sessions. The training sessions will begin by introducing the rationale and aims of the study. Raising awareness of the current sitting time and recognising the benefits of reducing sitting time The proposed strategies from previous focus groups will be discussed One or two strategies will be addressed in each training session After explaining the proposed changes, we will provide some examples on how to use these. Educator can share their ideas. The aim is to train all educators from each centre on the same day to ensure standardization of content delivery.	Self-efficacy Mastery experience Persuasion Learning process attention retention Learning process Production (goals and feedback, addressing barriers)
Provision of resources and equipment	After the training session we will provide educators with supporting written materials with the rationale, aims and strategies/activities to reduce pre-schoolers sitting time. We will provide them with adjustable standing desks.	Learning process Retention Motivation Self-efficacy: modelling
Follow-up Support	Every week the facilitator will visit the centre to follow-up in the intervention and to ask for feedback (perceived barriers or solutions). These will also be discussed at every training session given.	Learning process: Retention Production (goals and feedback, addressing barriers) Motivation
Performance monitoring and feedback	During the weekly visits, the facilitator will observe to see if educators are implementing the key factors of the intervention.	Self-efficacy: Mastery experience Persuasion Learning process Retention Production Motivation

Training session one was conducted in July 2016 to show educators how to use the two standing tables. In August 2016, educators received training session two and three on how to incorporate movement breaks with examples of music to support this and how to break up sitting time during nap and meal times. These sessions (30 to 45 min) were delivered in each intervention centre at specific times when it was suitable for all the educators to attend.

Figure 6. 1 The use of the circular height adjustable standing table and Lego on the easel in one of the intervention childcare centres in Wollongong, Australia, July-October 2016

6.3.5 Control group

The educators and children from the control centres did not participate in the training sessions or receive the intervention materials. They received the intervention materials after the post-test measurements (wait-list control) and were asked to continue with their normal routine during the intervention period.

6.3.6 Process and implementation measures

Intervention feasibility

Process data, including recruitment and retention rates were collected. The primary author wrote down notes after evaluating each training session. A week before collecting post-test data, interviews were done with the educators, which focused on attitudes, satisfaction and enjoyment toward the program and opinions of the activities and program content. Adverse events, such as complaints or injuries resulting from the intervention, were also recorded.

Fidelity

Intervention implementation fidelity was assessed using an observation list (Appendix M) completed on 10 occasions per intervention centre across the 12 weeks, relating to the five key intervention factors (Table 5).

Attendance to training sessions

Educators' attendance at intervention sessions was recorded at each session by the facilitator.

Intervention acceptability

Semi-structured interviews (face-to-face) were conducted with 13 educators from the two intervention centres. All interviews were audio-recorded digitally. Educators were interviewed after completing the 12-week intervention program. Topics covered included the acceptability of the intervention, educators' capability to deliver the intervention and perceptions on how strategies could be improved (Table 6.3). Interviews lasted between 5 and 20 minutes.

Table 6. 3 Interview questions used to evaluate the intervention

1. How has the standing pre-school project changed the way you work?
2. What changes have you observed when they are at the standing desk?
3. What component did you like best? Why?
4. How were the responses from the educators?
5. Were there any of the components that you did not really use? Why?
6. Is there anything you are not doing now from the intervention that you want to do in the future?
7. Any other experiences you want to share?

Demographics and height and weight

Each child's date of birth and sex were collected. Height and weight were measured and body mass index (BMI: kg/m^2) was calculated using a portable stadiometer (PE87; Mentone Educational Centre) and a calibrated electronic weight scale (Tanita BF-681; Tanita Corporation of America), according to standardised protocols (Wake, Salmon, Waters, Wright, & Hesketh, 2002). Weight status was calculated using LMSGrowth (Medical Research Council, United Kingdom) and UK reference curves (Cole & Lobstein, 2012).

6.3.7 Intervention efficacy

Sitting, standing and stepping

Outcome measures were assessed at baseline by the primary author and a research assistant, who were not blinded to group-allocation at follow-up. The primary outcome was total time spent in sitting, standing and stepping, assessed on each weekday that the child attended the centre during a 1-week period, using an activPAL (PAL Technologies, Ltd., Glasgow, UK). The activPAL has been shown to be a valid measurement tool for discriminating between different postures in young children (Janssen et al., 2014). The activPAL was placed on the child’s upper thigh (Davies et al., 2012; Janssen et al., 2014) using tape when arrived at the centre and removed when the child departed. On and off times were recorded by the research assistant. After the monitors were collected from each centre, data from activPAL were downloaded to a computer using activPAL software (v7.2.32) and exported to Microsoft Excel 2013 format file. A customised Excel macro was used to calculate total sitting, standing and stepping times from event files. The event file shows the time spent in each posture ('0' sedentary, '1' standing and '2' stepping). The calculation was based on the categorizations of sitting, standing and stepping from the event file. Every change from code 0 to code 1 or 2 was considered as transition/break from sitting to standing position. Times before arrival and departure were manually removed from the total minutes monitored. Children's data were included in the analysis if they provided at least 180 minutes on at least one day (Byun, Liu, & Pate, 2013). Mean breaks per hour in sitting were calculated as the total sum of the number of all sitting bouts (Dowd, Harrington, Bourke, Nelson, & Donnelly, 2012). Bouts of sitting were categorized as: < 1 min, 1–4 min, 5–9 min, 10–19 min, 20–29 min, or ≥ 30 min (Carson, Stone, & Faulkner, 2014).

Executive function

EF was measured using three iPad games; 1) inhibition ('Go/No-Go'), 2) visual-spatial working memory ('Mr Ant') and 3) task shifting ('Card Sorting') from the Early Years Toolbox (Howard & Melhuish, 2017). The Early Years Toolbox (EYT - http://www.eytoolbox.com.au) is a readily available and valid battery of iPad-based EF, language, self-regulation, and social development measures that have been designed and psychometrically tested with pre-school aged children (Howard & Melhuish, 2017). Prior to commencing, participants were given instructions. All iPad apps had built-in auditory instructions so data collectors could ensure the participant understood the instructions, clarified where necessary and remained on task. Each measure was designed to be brief engaging, and leverage the affordances of technology (e.g., animation, audio, and accurate capture of responses and response timings). Together, these tasks took ~20 minutes to complete. These measures were administered at both pre- and post-test.

6.3.8 Statistical analysis

Analyses were performed in STATA (version 13, StataCorp LP) and SPSS (version 21, IBM Corporation). Descriptive statistics were calculated using means and standard deviations for continuous variables and frequencies and percentages for categorical variables. Analyses of the primary and secondary outcomes were conducted using linear mixed (multi-level) models in STATA 13.1. The mixed model contained a random effect for time and centre nested within group, which was adjusted for baseline values and clustering. Analyses were performed on intention to treat basis, participants were included in the analyses if they had data at baseline or post-test. As a pilot study, this RCT was not adequately powered to detect statistically significant differences between groups. Therefore, standardized effect sizes were calculated to demonstrate effects. Effect sizes of approximately 0.2, 0.5 and 0.8 are considered small, medium and large, respectively (Cohen, 1988).

6.3.9 Qualitative data analyses

The digital audio files from each interview were transcribed verbatim. Data analysis followed the guidelines for thematic analysis outlined by Braun and Clarke (2006). The lead author read and listened to the audio recording to become familiarised with the data. Each transcript was then coded thematically; this was an open coding process, whereby meaningful quotes or key examples from educators were assigned a code. These emergent codes were then grouped together to develop themes (Braun & Clarke, 2006). Once themes were developed, the second and last authors provided critical feedback on the analysis and interpretations of the data. The peer debrief was concerned with the on-going process of data collection and analysis. This process took place through regular meetings between the research team.

6.4 Results

Of the 138 eligible pre-schoolers, signed consent forms were obtained from 115 (83%) pre-schoolers (Figure 6.2). Out of the 115 children, 33% of children attended in childcare 1 day/week, 38% of children 2 days a week, 21% 3 days a week and 8% 4/5 days a week. At baseline eight children (7%) did not have monitor data, but still participated in the EF tests and were therefore included in the analyses. Within the intervention centres there were four children who declined to wear the monitor compared to one child from the control centres. Twelve children (10%) did not have sitting time at post-test due to absence, wear time <180 minutes, refusal to wear monitor, or monitor malfunction.

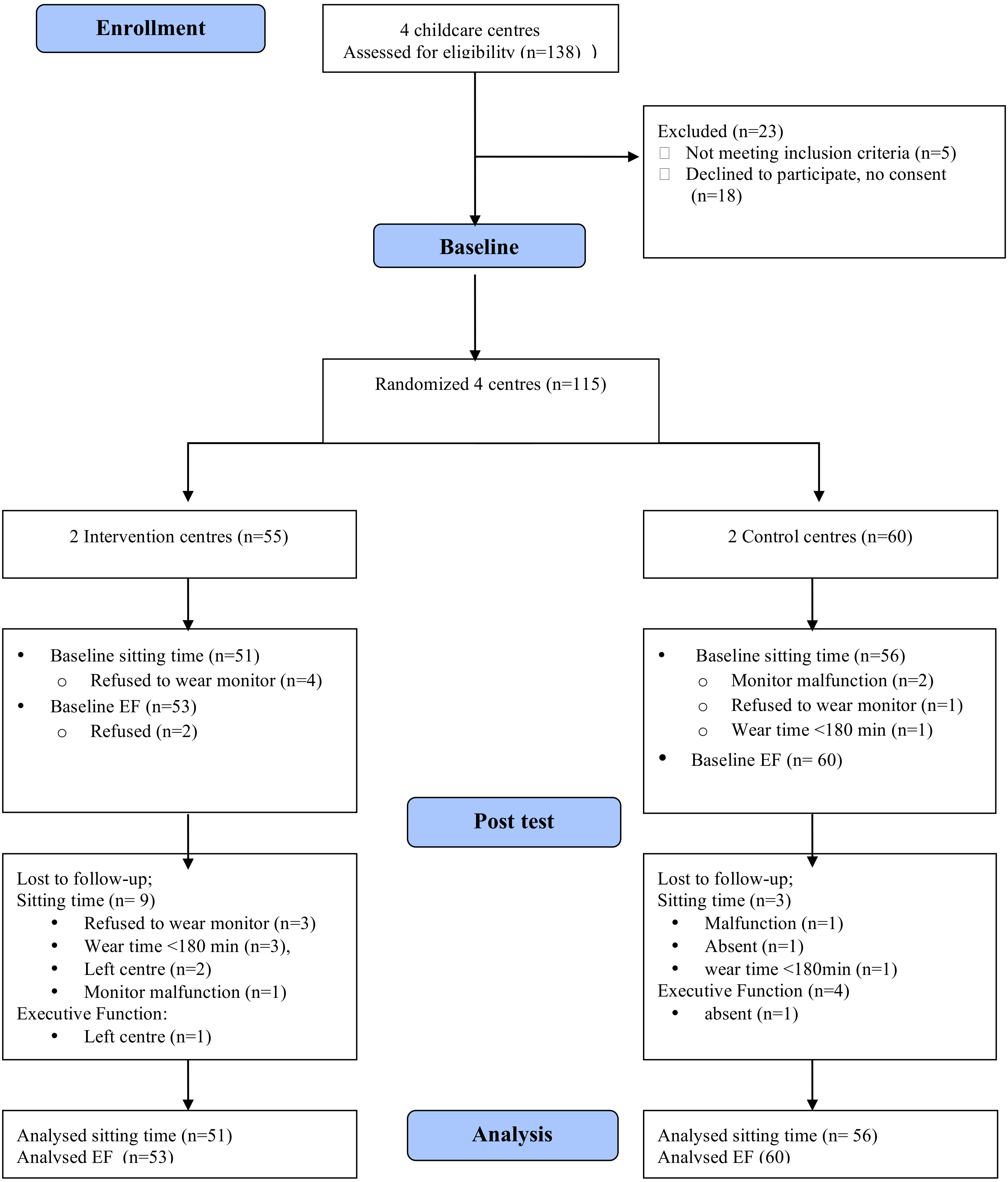

Figure 6. 2 Flow diagram

Descriptive characteristics are shown in Table 6.3. The pre-schoolers in the intervention group included more boys compared to the control group, however there were no statistically differences. Compared with the intervention group, the mean monitor wear time at baseline was significantly higher in the control group, 386.2 (±68.2) and 348.2 (±74.7) minutes per day, respectively. At post-test this was 384.9 (±53.5) minutes for the control group and 374.0 (±76.0) minutes for the intervention group. No other significant differences in baseline characteristics were found. Compliance with IOM recommendation for sedentary behaviour in the intervention group was 72% and 62% for the control group.

Table 6. 4 Characteristics of participants at baseline and post-test (mean, SD)

Characteristics	**Baseline**	
	Intervention (n=55)	**Control (n=60)**
Mean age (years)	4.1 (0.7)	4.2 (0.6)
Sex, (% male)	47	40
Height (cm)	103.1 (5.7)	104.3 (5.9)
Weight (kg)	17.4 (2.3)	17.8 (2.4)
BMI (kg/m^2)	16.4 (1.4)	16.3 (1.3)
Weight status		
Underweight (n, %)	2 (4)	2 (3)
Normal weight (n, %)	44 (80)	44 (77)
Overweight (n, %)	6 (11)	11 (18)
Obese (n, %)	3 (6)	1 (2)
Wear time		
Days (n, SD)	2.0 (1.0)	2.2 (1.1)
Wear time (min/day)	348.2 (74.7)*	386.2 (68.2)

Note: BMI = body mass index;
*Significant differences between groups in wear time at pre-test (P=0.007)

Intervention feasibility

Fidelity

The mean total fidelity score for intervention centre 1 and 2 were 77% vs. 70%, emphasising overall good adherence to the protocol. Implementing active story time and movement breaks were the two factors that had the poorest adherence (Table 6.3).

Table 6. 5 Summary of fidelity scores across five key intervention components

Observations	Intervention centre 1		Intervention centre 2	
1. Were the standing desks used?	Yes = 10 No = 0	100%	Yes = 10 No = 0	100%
2. Was the easel used?	Yes = 2 No = 4	50%	Yes = 6 No = 0	100%
3. Did the educators implement active story time?	Yes = 1 No = 7	17%	Yes = 3 No = 3	50%
4. Did the educators implement a movement break throughout the day?	Yes = 6 No = 2	70%	Yes = 3 No = 5	38%
5a. Were children given the opportunity to do quiet activities if not wanting to nap/rest?	Yes = 4 No = 0	100%	Yes = 1 No =3	25%
5b. Did children scrape their own food in the bin?	Yes = 4 No = 0	100%	Yes = 1 No = 3	75%
5c. Were children standing up to get their own drink?	Yes = 4 No =0	100%	Yes = 4 No = 0	100%
Total fidelity score		77%		70%

Intervention acceptability

Acceptability of intervention content

A total of 11 educators and 2 Directors (37.5 ± 13.8years, 100% female) from both intervention centres participated in the interviews from both intervention centres.

The educators were positive about the intervention to reduce sitting time in pre-schoolers. At first, most educators were uncertain about the height adjustable standing table. One Director stated; '*I think in our first team meetings, when we talked about you coming to do this, there was a lot of uncertainty. How is this going to work?'* However, the educators realised how quick the children adapted to the new environment. '*I think, after the first few days, the staff saw how easily the children adapted. Oh there are no chairs we have to stand. It wasn't an issue for the children, it was us as the educators that are so used to the routine that we were the ones that had to adapt.*'

The educators noticed some differences in the children's way of playing. More social play, better engagement, collaboration, calmness and higher concentration levels were the most positive changes resulting from the intervention, especially the standing table and easels. '*I like the standing desk the most. I was able to do more with the kids, a bigger group, more fitted around the table, they communicated easier nobody is getting excluded, its good.'*

Components that were less used in both the intervention centres according to the educators were active story time and movement breaks. '*We really need to do some more standing breaks, for example in between reading books getting them to stand up and do a dance or something and sit back down.'* Reasons for not implementing these components included time constraints and simply forgetting to implement them. '*We probably didn't use as much of the* *active story time this term, because we had so much on.'* One educator suggested having professional discussions with the team and reminding each other.

Overall the intervention had changed both centres positively as they were more aware of the childcare environment. '*It's changed us in a positive way. I think we re-think about the environment. We look at areas, differently. I think we really look at the environment and the natural environment and see how children are playing and it just redirects their play naturally.'* But they also became more aware of pre-schoolers sitting time and supervision enhanced. *'I think it has been a positive for the children and it has really made us as educators think about how much sitting they actually doing. It is actually more manageable as an educator doing groups and things like that.'* Thus, based on interview data, the intervention appeared to be acceptable to educators, although active story time and movement breaks were implemented fewer times as intended.

Primary outcomes

Sitting, standing and stepping

Sitting time at baseline was higher in the control centres (33.03 min/hr ±1.65, 55.06% ±2.74) compared to intervention centres (29.17 min/hr ±1.65, 53.44% ±2.78) (Table 6.6). The proportion of standing at baseline was on average higher in the intervention group (16.96 min/hr ± 0.95, 27.93% ±1.06) versus the control group (15.39 min/hr ± 0.91, 25.71% ±1.01). The proportion of stepping at baseline was on average higher in the control group (11.51 min/hr ± 1.47, 23.59% ±2.43) versus the intervention group (11.01 min/hr ± 1.48, 18.34% ±2.44). No differences were found and the effect sizes were small. Over time, the proportion of sitting per day tended to decrease in both groups, but the change in time between groups was not significant (P=0.51, P=0.43, P=0.06).

Sitting bouts and total breaks

Sitting breaks decreased in both groups, however no differences were found between intervention and control group (Table 6.6). Over time, the number of breaks per hour did not differ between intervention and control group (*P*= 0.29).

Secondary outcomes

Executive function

There was a significant difference in shifting between the baseline measures in the intervention (3.05 ±0.52) and control group (4.87 ±0.50), however no significant difference at post-test. Likewise, no significant intervention effects for inhibition or working memory were observed (Table 6.6).

Table 6. 6 Change in sitting, standing and stepping time, sitting breaks/bouts and executive function scores from pre to post

Outcome	Intervention (mean, SE)		Control (mean, SE)		Mean difference in Change between groups (*M*, 95% CI)[a]	Effect size (Cohen *d*)	*P* value
	Pre	Post	Pre	Post			
Sitting (%/day)	53.44 (2.78)	48.24 (2.79)*	55.06 (2.74)	48.62 (2.79)*	1.24 (-2.42, 4.89)	0.13	0.51
Standing (%/day)	27.93 (1.06)	31.17 (1.08)*	25.71 (1.01)	27.79 (1.04)*	1.16 (-1.69, 4.01)	0.16	0.43
Stepping (%/day)	18.34 (2.44)	20.19 (2.45)*	19.18 (2.43)	23.59 (2.43)*	-2.56 (-5.28, 0.15)	-0.38	0.06
Bouts of sitting per hour							
<1 min	34.55 (1.95)	33.19 (1.96)	28.83 (1.88)	26.67 (1.90)**	0.81 (-3.36, 4.99)	0.07	0.70
1-4 min	4.52 (0.30)	3.97(0.31)	5.06 (0.29)	4.82 (0.30)	-0.29 (-0.93, 0.33)	-0.20	0.35
5-9 min	0.84 (0.05)	0.85 (0.05)	0.99 (0.05)	0.84 (0.05)*	0.14 (-0.05, 0.33)	0.28	0.16
10-19 min	0.40 (0.04)	0.35 (0.04)	0.34 (0.03)	0.35 (0.04)	-0.06 (-0.02, 0.09)	-0.16	0.43
20 – 30 min	0.07 (0.01)	0.05 (0.02)	0.06 (0.01)	0.06 (0.01)	-0.01 (-0.06, 0.04)	-0.05	0.77
>30min	0.01 (0.003)	0.00 (0.004)	0.01 (0.003)	0.00 (0.004)	0.01 (-0.01, 0.02)	0.27	0.39
Breaks in sitting per hour	40.49 (2.22)	38.53 (2.24)	35.28 (2.16)	32.69 (2.18)	0.64 (-3.62, 4.89)	0.06	0.29
Executive function							
Inhibition	0.56 (0.03)	0.70 (0.03)	0.58 (0.028)	0.73(0.029)*	-0.01 (-0.09, 0.07)	-0.03	0.17
Working memory	1.31 (0.11)	1.93 (0.11)	1.52 (0.11)	2.03 (0.11)*	0.11 (-0.17, 0.39)	0.15	0.44
Shifting	3.05 (0.52)	5.33 (0.53)	4.87 (0.50)	7.23 (0.50)**	-0.07 (-1.81, 1.67)	-0.01	0.94
BMI (kg/m^2)	16.40 (0.21)	16.23 (0.21)	16.34 (0.20)	16.06 (0.20)	0.11 (-0.12, 0.34)	0.18	0.34

*Note.*SE= *standard error; CI=confidence interval; min= minutes; BMI = Body Mass Index*

[a] Adjusted for group and baseline value of outcome variable

[b] Standardized effect sizes were calculated on complete cases (based on a t-test) and calculated from means and standard deviations using the baseline values as the denominator.

* Significant differences between pre and post within intervention and control groups (*P*<0.05)

** Significant difference between control and intervention (*P*<0.05)

6.5 Discussion

The purpose of this pilot intervention was to assess the feasibility, acceptability and potential efficacy of a childcare-based intervention to reduce sitting time among pre-schoolers at childcare. The findings suggest that this intervention was feasible as process data showed that pre-schoolers adapted to the changes in environment and routine and based on the fidelity scores educators were able to implement most of the key intervention factors. Likewise, there was clear support from the educators for the acceptability of the intervention as interview data indicated they have had positive experiences. For example, in using the circular height-adjustable standing tables, educators noticed positive changes in pre-schoolers social play, e.g. better collaboration. Regarding potential efficacy, no intervention effect was apparent in pre-schoolers objectively measured sitting time and EF.

To date, no known intervention studies on reducing sitting time in pre-schoolers have reported on fidelity scores. However, consistent with studies of physical activity interventions (Alhassan et al., 2016; Barber et al., 2016), this sitting intervention was predominantly considered feasible and acceptable according to educators and children. In the current study, the fidelity scores for *professional development* and *implementing the key intervention factors* were high, indicating it was feasible for childcare centres to implement the intervention, particularly the standing workstations. However, three factors from the intervention that had poorer adherence were: implementing active story time, movement breaks, and the use of the standing easel in one intervention centre. Each intervention centre personalized the implementation to suit their setting. Therefore, some difficulties appeared with completing all the intervention tasks due to responsibility to comply with childcare demands. Active story time and movement breaks could have received more guidance from the facilitator during the intervention. Thus, training sessions and guidance may need to be revised to achieve the goals. Notwithstanding, there was a high level of support offered by the Directors and educators of the centres and the prospective benefits of the intervention noticed by the educators may have contributed to high implementation rates for the other factors. Several studies suggest that strong, positive leadership is key for implementation of interventions within organisations (Herold, Fedor, Caldwell, & Liu, 2008; Scott, Mannion, Davies, & Marshall, 2003), which was evident in this study. The findings of this intervention addressed issues that were not previously considered and can be used to inform the design of future larger trials.

The intervention was acceptable according to positive feedback from the Directors and educators. Several factors may have contributed to this. First, objectively measured sitting, standing and stepping time in pre-schoolers was measured four years ago in the same centres (Ellis et al., 2016), meaning they were familiar with the study and researcher. Second, the intervention was designed in response to formative research with educators on their perceptions of how to reduce and break up prolonged sitting time in pre-schoolers (Ellis et al., 2017). A series of smaller studies are encouraged to test intervention factors, such as suitability of content, and to maximize achievement of outcomes (Stevens, Taber, Murray, & Ward, 2007). In this study the circular height-adjustable standing tables had the highest acceptability according to educators. To our knowledge this is the first study to use the circular height-adjustable tables in the childcare setting. Other studies have used the height-adjustable tables in primary school settings (Aminian, Hinckson, & Stewart, 2015; Carson et al., 2013; Clemes et al., 2015; Contardo Ayala et al., 2016; De Craemer et al., 2016), however only two of these studies mentioned acceptability (Aminian et al., 2015; Hinckson et al., 2013). According to these studies, teachers reported positive pedagogical outcomes as the circular standing table encouraged the children in their social interactions. Teachers also noted that children behaved better in this dynamic environment and that the table was useful for group work and supervision (Aminian et al., 2015; Hinckson et al., 2013). These responses were similar to this intervention, suggesting that the circular height-adjusted tables have a positive influence on children's behaviour. However, some of the intervention factors did not get implemented as intended. Potential reasons were time restrictions and simply forgetting them as they were in the habit of following a routine. Therefore future interventions should focus on finding strategies to enhance implementation of these factors by, for example, putting up visual reminders in common areas for childcare educators.

The intervention showed a minimal effect on the primary and secondary outcomes of sitting, standing, stepping time and EF. These results are consistent with a similar RCT in pre-schoolers, where no intervention effect was found on objectively measured sedentary time during school hours (De Craemer et al., 2016). Potential reasons for the minimal effect on sitting time in this study could be due to the short intervention period (12 weeks). According to Biddle et al (2011) interventions that focused on reducing sedentary time and lasted less than four months had small intervention effects. Future interventions and pilot studies should consider longer periods to improve the effectiveness of the intervention. Another reason could be the different weather conditions during data collection for each centre. O'Connor and Temple (2005) reported that the weather had an important influence on physical activity levels in children at childcare. Furthermore, most of the intervention factors were implemented indoors, however outdoor time was also included in the assessments of sitting time during childcare. Since outdoor time has shown to be associated with higher activity levels in children at childcare (Copeland, Kendeigh, Saelens, Kalkwarf, & Sherman, 2011), future intervention studies should consider having indoor and outdoor time as separate outcomes. According to the fidelity scores and interviews, both intervention centres had low scores for implementing active story time and movement breaks. There were also differences in scores for the standing easel and nap and mealtimes, which may influenced the results. However, as this was a small and short-term intervention, this pilot study offers important insight for the fast-growing field of research aiming at reducing and breaking up prolonged sitting time in pre-schoolers.

In this study, no intervention effect on EF scores was found. To our knowledge, no studies have tested this in pre-schoolers. There has been one systematic review on physical activity and cognitive development in pre-school children (Carson et al., 2016). This review highlighted there is a small body of evidence, which is primarily weak in quality. It provided some preliminary evidence that higher duration/frequency of physical activity may have beneficial effects on cognitive development, which is consistent with evidence in older children and adults. However, future research is needed to strengthen the evidence in this area (Carson et al., 2016). There are plausible mechanisms through which changes in sitting time might affect EF (Voss et al., 2014). Evidence suggests this might be due to less efficient glucose metabolism, reduced insulin sensitivity and insulin resistance (Voss et al., 2014). In the current study, the hypothesized mechanism for improving EF was decreased sitting time.

However, as there was no effect of the intervention on sitting time, it is no surprising that there was not an effect found for EF.

The current study has several strengths and limitations. First, this pilot trial used both qualitative and quantitative data analyses. Second, the use of an objective and direct measure to assess sitting, standing and stepping time, thus overcoming some of the limitations in other assessment methods, such as proxy reports. Third, training educators to implement the intervention, which enhances sustainability. Despite its strengths, this study includes some limitations. First, the small sample size, which reduces the statistical power and ability to identify differences in sitting time and EF between groups. Second, the assessor was not blinded to the intervention groups at post-test; however, to reduce this bias sitting time and EF were assessed using objective measures. Third, a possible "placebo effect" in the control childcare centres. The educators from the control childcare centres knew what the aim of the intervention was and could have potentially influenced the typical behaviours of the children in the week of measurement. In an effort to ensure the practices in the control centres did not change drastically, the first author visited the control centres and had personal communication with the directors of the control centres once during the intervention and encouraged them to maintain their current practices until the end of the intervention period. Lastly, the compliance of the children wearing the activPAL garter for at least three hours while at childcare. Twenty pre-schoolers were not included due to not wanting to wear the activPAL garter or were lost to follow-up.

6.6 Conclusion

To conclude, a childcare-based intervention to reduce pre-school children's sitting time was feasible and acceptable, but the intervention had a minimal impact on children's sitting time and EF in this pilot study. Implementation fidelity was high, and educators saw the intervention as acceptable and deliverable. Future studies including larger sample sizes, additional strategies to professional development and longer follow-up periods are recommended to evaluate program efficacy and effectiveness

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Chapter 7

General Discussion and Conclusions

7.1 Aim of thesis

The overall aim of this Doctorate was to address several gaps in the research related to sedentary behaviour and health in young children and to conduct a series of studies to add to the evidence-base in the area of sedentary behaviour and health in children aged 1 to 5 years at childcare. The five main objectives were to (1) examine the prevalence and socio-demographic distribution of sitting time (as well as standing and stepping time) among children aged 1 to 5 years whilst in childcare; (2) understand early childhood educators' perceptions of young children's sitting time in childcare, the potential factors that contribute to high levels of sitting, and potential modifications that could be made within childcare centres to reduce total and prolonged sitting among children during childcare; (3) examine the acute effects of a 'sit less, stand and move more' pre-school day on executive function and musculoskeletal health in pre-school aged (3-5 years) children; (4) examine if there are compensatory effects made by pre-school aged children on energy expenditure and energy intake as a result of a modified "sit less, stand and move more" pre-school day; and (5) conduct a pilot RCT in childcare settings to examine the feasibility, acceptability, and potential efficacy of a childcare-based intervention to reduce sitting time among pre-schoolers, and to assess whether a reduction in sitting time has an effect on executive function (EF).

7.2 Main findings

The study described in Chapter 3 was one of the first studies to report on objectively measured sitting time and physical activity, socio-demographic distribution and compliance with both the Institute of Medicine (IOM) sedentary behaviour and physical activity recommendations in 301 young children (1 to 5 years) from 11 childcare centres. This study reported that children aged 1 to 5 years spent around 50% of their total time at childcare sitting, 30% standing, and less than 20% being physically active. Socio-demographic differences were found in sitting, standing and physical activity among young children. Specifically, boys and toddlers were less sedentary compared to girls and pre-schoolers. Pre-school children had significantly greater 5-9 minute sitting bouts compared to toddlers. Furthermore, around half of the children complied with the IOM recommendation for sedentary behaviour, but less than one in five children met the IOM recommendation for physical activity.

Chapter 4 focused on identifying childcare educators' perceptions of and solutions to reducing sitting time in young children at childcare. Participants were 87 educators from 11 childcare centres, who were involved in a focus group at their childcare centre. A semi-structured schedule was developed based on the problem-and-solution tree tool to examine the educator's perceptions of the causes of and potential solutions for modifying young children's high sitting time in childcare. This qualitative study is the first study in Australia to explore the educators' perceptions of the factor that influence children's sitting time in childcare centres and potential solutions to reduce this. The study showed that childcare educators were unaware of the current levels of sitting time in young children at childcare. Educators identified that childcare practices, the physical environment and parental and educator values were factors that could be modified to reduce young children's sitting time in childcare.

In Chapter 5, the acute effects of a 'reduced sitting pre-school day' on executive function and musculoskeletal health in 29 pre-schoolers was examined. Furthermore, whether or not children compensated in the 48hrs immediately after a 'reduced sitting pre-school day' by increasing their energy intake or decreasing their energy expenditure was also investigated. Children completed two conditions in a laboratory, each lasting 2.5h in random order: a typical pre-school day (50% sitting) and a reduced pre-school day (25% sitting) where most sitting activities were replaced with standing activities. This study found that replacing sitting time with standing did not result in acute changes in executive function and musculoskeletal health. However, small effect sizes were seen in hamstring length, hip extension strength, gastrocnemius length and stability. Furthermore, no compensatory changes were seen as energy intake and energy expenditure from the participants did not differ between the typical and reduced sitting condition.

Chapter 6 investigated the feasibility, acceptability, and potential efficacy of a "sit less, stand and move more" day on executive function and musculoskeletal health (over a three month period) among 115 pre-school aged children. The intervention strategies included measures to reduce or break-up total and prolonged sitting time. This intervention programme was found to be feasible and acceptable by the educators, but the intervention had a minimal impact on pre-schooler's sitting time and executive function in this pilot study.

In summary, the findings from the four studies have added to the evidence-base in the area of sedentary behaviour and health in children aged 1 to 5 years. The findings from this thesis suggest that young children are an important target group for reducing sitting time, given that only 56% complied with sedentary behaviour recommendations at childcare. The significance of reducing sitting time in young children at childcare, especially for girls and pre-schoolers, may be an essential public health message for those working with young children. Different strategies were developed and tested with the help of childcare educators to reduce sitting time in young children at childcare, specifically relating to childcare practices, physical environment and equipment. Childcare educators were able to feasibly implement these modifications in the childcare setting. Furthermore, this Doctorate contributed to the evidence base on the health effects of reducing sitting time in young children at childcare. Overall, reducing sitting time did not acutely affect children's executive function and musculoskeletal health. However, small improvements were seen in some musculoskeletal health measurements, which might be promising for young children's health in the long term.

7.3 Discussion

When sitting time prevalence and patterns were measured objectively in Chapter 3, approximately 50% of young children's time at childcare was spent in sedentary behaviour or sitting. More recent studies have described comparable daily estimates of objectively measured total sitting time using accelerometers in children at childcare (Andersen et al., 2017; Carson et al., 2016; Møller et al., 2017). While young children engage in high levels of sitting time, as shown in Chapter 3, the accumulation of that time was mostly in shorter bouts with a high frequency of breaks, suggesting that children's sedentary behaviour is sporadic. Only a small number of studies have objectively assessed breaks and bouts of sitting across the day in childcare settings; these have showed similar results (Berglind & Tynelius, 2018; Carson et al., 2016; Kuzik, Clark, Ogden, Harber, & Carson, 2015). Carson et al. (2016) and Kuzik et al. (2015) showed that the majority of young children's time at childcare was also spent in 1-4 minute sitting bouts. However, all three studies used accelerometers (Actical or ActiGraph) to measure sedentary bouts, which have difficulties in accurately classifying differences between sitting and standing still. This limitation may cause misclassification of sedentary bouts, so future studies should use inclinometers, such as the activPAL in Chapter 3, to minimize measurement error (Ridgers et al., 2012). Regardless, encouraging and supporting children from a young age to frequently break up their sitting time may establish habits early in life that will continue into adolescence and adulthood.

The study in Chapter 3 is furthermore unique in reporting on guidelines adherence in sedentary behaviours and physical activity in young children. Results indicate that almost 45% of the children did not meet the guidelines, suggesting that there is a need for research to understand why guidelines are not being met and for interventions to promote strategies to improve compliance.

The studies in Chapter 5 and 6 could not establish a causal relationship between sitting time and developmental and health outcomes in pre-school children. However, accumulating evidence continues to suggest that high levels of total and prolonged sitting time should be avoided by all age groups, including children (Owen, Healy, Matthews, & Dunstan, 2010; Poitras et al., 2017). This is supported by the recently developed Australian 24-hour Movement Guidelines for the Early years (Birth to 5 years) using an integrated movement behaviour model including sedentary, physical activity and sleep behaviours (Okely et al., 2017). These guidelines state that pre-schoolers should not be restrained for more than 1 hour at a time or sit for extended periods. In addition, when pre-schoolers are sedentary, caregivers are encouraged to engage with them through activities such as reading, singing, puzzles and storytelling (Okely et al., 2017). These guidelines, however, are not specifically targeted to the childcare setting; the Institute of Medicine (IOM) is the only known organization who have recommendations for sedentary behaviour in childcare settings (Institute of Medicine, 2011). The recommendation relating to sedentary behaviour in childcare settings by the IOM suggests that young children should be allowed to move freely and that sitting or standing still should be limited to 30 minutes at a time (Institute of Medicine, 2011). However, this guideline is somewhat inconsistent with the most recent updated definition of sedentary behaviour by Tremblay and colleagues (2017), as standing is not included in the current definition of sedentary behaviour. This presents a challenge for researchers and practitioners in the assessment and operationalization of these recommendations in practice. It is suggested that this inconsistency is resolved in the near future by developing recommendations for sedentary behaviour in young children at childcare based on the current definition of sedentary behaviour.

Excessive sitting in childhood may still set children on a path for poorer health later in life. Evidence has shown that total sedentary time tracks from early childhood into childhood and adulthood (Biddle, Pearson, Ross, & Braithwaite, 2010; Jones, Hinkley, Okely, & Salmon, 2013). Therefore, children with high levels of sitting time are more likely to experience higher levels in adulthood. This is concerning, since prolonged periods of sitting in adulthood has been linked with associated health risks (Daneshmandi, Choobineh, Ghaem, & Karimi, 2017; de Rezende, Lopes, Rey-López, Matsudo, & do Carmo Luiz, 2014; Hamilton, Healy, Dunstan, Zderic, & Owen, 2008; Owen et al., 2010; Tremblay, Colley, Saunders, Healy, & Owen, 2010; Voss, Carr, Clark, & Weng, 2014). Though less consistent, a number of studies have found significant associations between sedentary behaviour and health outcomes among younger children (Poitras et al., 2017). As results from Chapters 5 and 6 suggest, even though no acute effects were seen in EF or musculoskeletal health, high levels of sitting time might still lead to a positive energy balance, and possibly an increase in unhealthy weight, because children do not appear to compensate. Therefore, while the immediate health impact for young children of reducing sitting may be small, it has the potential to result in improved health outcomes in the longer term, if sustained.

Few interventions in childcare have attempted to reduce sitting time by modifying existing daily activities. Most interventions usually target young children with the primary aim to increase physical activity and a secondary aim to reduce sedentary behaviour in young children throughout the childcare day (Alhassan et al., 2012; Alhassan, Nwaokelemeh, Lyden, Goldsby, & Mendoza, 2013; De Bock, Genser, Raat, Fischer, & Renz-Polster, 2013). The reason why interventions focusing on physical activity affect sedentary behaviour is because these behaviours are interrelated. As they are both movement behaviours on the same continuum, increases in sedentary time may be at the cost of reduced physical activity, particularly light-intensity physical activity (LPA). Sedentary behaviours have been shown to have separate correlates to physical activity (Chapter 2), therefore to target sedentary behaviour, specific interventions should be implemented. More interventions should focus on finding ways to reduce both sedentary time which should be replaced with another movement behaviour (Carson et al., 2016), and have as many children comply with sedentary behaviour and physical activity guidelines.

The intervention in Chapter 6 was designed based on the formative research reported in Chapter 4, with educators giving their perceptions on how to reduce and break up prolonged sitting time in pre-schoolers. The educators identified key challenges that may inhibit breaking up prolonged sitting time in their childcare setting. This information was used in the development and testing of the acceptability, feasibility and potential efficacy of the strategies for overcoming these barriers.

The studies in Chapters 5 and 6 found that substituting some of pre-schoolers sitting time with standing did not have a negative impact on their executive function, which is a positive result from an educator's perspective. These modified routines and environments were flexible and adjustable to the learning activities usually undertaken in childcare, and the results showed that these were feasible for educators to adopt and implement. Moreover, the sitting reduction intervention is likely to be cost-effective (besides the height-adjustable standing desks), requiring no additional resources beyond the ones that already exist in childcare.

7.4 Strengths

The series of studies undertaken for the purpose of this PhD thesis resulted in a number of contributions to the field of sedentary behaviour research in young children. These studies were the first to: 1) measure sitting time with the activPAL in young children at childcare in Australia and internationally; 2) report on compliance of the IOM recommendation for sedentary behaviour in childcare internationally; 3) explore educators' perceptions of the factors that influence children's sitting time in childcare centres and potential solutions to reduce this; 4) examine the acute effects of a typical and reduced sitting pre-school day on executive function and musculoskeletal outcomes in young children; and 5) Develop and evaluate modifications to childcare centres in Australia to attempt to reduce sitting in pre-schoolers.

Furthermore, the use of a large and diverse sample from different geographical areas in the study reported in Chapter 2 was a strength of the research. This sample also included children aged less than three years, for which there is limited evidence in the literature. As a result, this will strengthen generalizability of the findings in Australian young children and childcare educators. Also, in Chapter 4 a large sample size of childcare educators was used for a qualitative analysis..

The examination of objectively measured sedentary behaviour and patterns of sedentary behaviour in young children in this thesis is another strength. Most studies in the literature have investigated screen time as one type of sedentary behaviour. However, screen time is only one of several types of sedentary behaviour that young children engage in and may not represent their total habitual sedentary behaviour. Additional strengths of this thesis include the novel approach used to objectively assess sitting time in young children whilst at childcare in Chapters 2, 4 and 5. The activPAL was able to distinguish the different postures of sitting, standing and stepping in young children.

Another strength of this thesis was the use of different research designs (cross-sectional, randomized control trial, qualitative and quantitative) throughout Chapters 3 to 6. This allowed for the examination of sitting patterns in a large group of young children, as well as examining causal relationships in a more controlled setting and applying the modified strategies in a “real-world” environment.

Lastly, the use of the different phases of the Behavioural Epidemiological Framework to identify effective methods of reducing sedentary behaviour in young children has been a strength in this thesis. These phases are (1) establishing the links between the behaviour and health outcomes, (2) developing behaviour measures, (3) identifying influences on the behaviour, (4) evaluating interventions to impact the behaviour, and (5) translating findings into practice. This knowledge will help to formulate relevant public health policies to reduce sedentary behaviour in young children at childcare.

7.5 Limitations

Despite the strengths, a number of limitations should be considered when drawing conclusions. One key limitation of this thesis is the use of a cross-sectional design in Chapter 3; therefore, no conclusions could be made related to causality (e.g. if overweight children sit more, or if sitting more is likely to cause children to become overweight). However, these cross-sectional studies are needed to create hypotheses for further research. Further, Chapter 3 and Chapter 6 only examined a short period of the child’s sedentary time. A limited number of days of measurement may not be representative of the true levels of time spent sedentary at the individual level. However, the aim was to represent LMVPA at the centre level from individual participant samples. Therefore, less stringent inclusion criteria (e.g., ≥1 day) was acceptable because these errors may not bias centre-level estimates, and loss of precision may be overcome by increasing sampe size (Matthews, Hagstromer, Pober, Bowles, 2012).

Another limitation was the low response rate in Chapter 3. A considerable proportion of the consented children had to be excluded due to not having worn the accelerometer for the minimum number of days. This was mainly because the wear time was not valid. An explanation for the short wear time was due to the activPAL garter falling down in a lot of children. This issue was resolved towards the end of data collection by using double sided tape on the inside of the garter. Furthermore, the inclusion of naptime for the small proportion of pre-schoolers who might still nap may have impacted on the estimates of their behaviours.

One further limitation relating to the study reported in Chapter 5 was the absence of the Energy Expenditure data due to technical issues with the calorimeter room. However, there were still important outcomes measured and reported in Chapter 5, which added to the evidence related to the health consequences of sedentary behaviour in young children.

7.6 Future research

The findings from this thesis have identified key opportunities for future research in this area. These opportunities for researchers and practitioners are discussed below.

Chapter 3 was the first study to examine the adherence to the IOM recommendation for sedentary behaviour, including sitting and standing still, in young children at childcare. However, this guideline is inconsistent with the most recent updated definition of sedentary behaviour by Tremblay and colleagues (2017), as standing is not included in the current definition. Therefore, future research that will focus on updating and/or revising sedentary behaviour guidelines should make use of the GRADE-ADOLOPMENT approach (Okely et al., 2017). For example, the current Australian Movement Guidelines were based on the Canadian Guidelines. The advantages of this included being able to extend the Canadian Guideline development work to the Australian context and consequently develop guidelines in a much shorter time period and at a considerably reduced cost. The use of this approach showed that it is feasible for other countries to consider when developing and/or revising national movement behaviour Guidelines.

In Chapter 3 it was identified that girls and pre-schoolers spent more time in sedentary behaviour. Therefore, future research should focus more on reducing sedentary behaviour among girls' and pre-schoolers' during the early years. Also, more studies should use the activPAL to measure sitting, standing and stepping, as it is able to distinguish different postures. These findings could be used to inform the development of interventions to reduce sitting time in childcare. Future research should engage childcare educators in sharing their perceptions on reducing sitting time, as this also contributes to the development of the intervention. The identification of periods of high levels of sitting time has important implications for public health strategies that aim to reduce overall and prolonged periods of sedentary behaviour.

In regards to sedentary behaviour and health outcomes in young children, Chapter 5 highlights that longitudinal studies are needed to understand if sitting time impacts executive function, musculoskeletal health and other health outcomes on the long term.

Chapter 6 addressed issues that may have limited intervention effects, such as a lack of blinding of the assessors, a possible placebo effect and implementation fidelity of the educators, which have previously not been considered. These issues can be used to inform the design of future larger trials. Future interventions should focus on finding strategies to enhance implementation of factors that were not implemented as intended. In addition, future intervention studies should consider having indoor and outdoor time as separate outcomes.

Furthermore, this suite of studies highlights the complexity of accurately capturing and understanding patterns of sitting time among young children. Several findings can be drawn from these studies. Firstly, the young age of the participants poses unique challenges for measuring sitting time. Some children were not interested in wearing the monitor, and especially in Chapter 3, there were difficulties in securely attaching the activPAL to the child's leg without the device falling down. Second, the childcare environment in which the children were being assessed in Chapter 3 and 6 is important to consider given the potential variations in each centre that influence the sedentary levels being recorded. Given that the childcare setting plays an important role in most young children's lives, it is important to support these unique settings in their efforts to discourage prolonged sitting time and to minimise total sitting time.

Lastly, future studies should use a responsive model of research, whereby researchers feed data back to participants and stakeholders. Data from Chapter 3, 5 and 6 were reported back to the childcare organisations, childcare directors and educators to inform them about the current levels of sitting time in young children. Due to this form of community based participatory research, they supported the development of interventions to reduce sitting time in young children at childcare.

7.7 Implications

Several of the findings from the four Chapters in this thesis have important implications for public health and early childhood education. Given the proportion of sitting time measured among young children in Chapter 3, increased efforts are needed to confirm these findings and to examine ways in which prolonged periods of sitting can be broken up or limited. These findings would be important for health education/promotion programs with parents and childcare providers as it is important to ensure toddlers and pre-schoolers are developing healthy sedentary and physical activity behaviours early in life.

Furthermore, to ensure childcare centres are aware of how much time young children should spend sitting, future national guidelines should continue to develop separate sedentary behaviour recommendations for young children at childcare.

Moreover, to reduce and break up sitting time among young children whilst in childcare, potential strategies have been developed in Chapter 4 and evaluated in Chapters 5 and 6 within this thesis. These strategies may be important to consider for future interventions and initiatives among young children in childcare. Chapter 4 shows that engaging childcare educators in sharing their perceptions and ideas is an important first step to creating and implementing an intervention to reduce sitting time in young children. Childcare educators could receive workshops or course material on how to reduce sedentary behaviour and promote physical activity at childcare.

7.8 Conclusions

This Doctorate aimed to add to the evidence-base in the area of sedentary behaviour and health in young children. Findings from this Doctorate have contributed evidence and provided a better understanding of this growing research area. The four studies (cross-sectional, qualitative and experimental) have provided key findings on the prevalence, health consequences and intervention development and evaluation of sitting time in young children. It was shown that many young children sat for almost half of their day at childcare, in particular girls and pre-schoolers, and that half of them were not meeting the sedentary behaviour recommendation. The findings also provided insight on the health effects of sitting time in young children, in particular executive function and musculoskeletal health. Finally, the findings extend the knowledge-base on which potential strategies to use to reduce sitting time in pre-schoolers at childcare, as these show to be acceptable and feasible in the intervention. These research findings will hopefully provide guidance for the development of interventions and childcare policies to reduce young children's sitting time to optimise young children's health and well-being.

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Chapter 8

Appendices

Appendix A - Ethics approval Chapter 3 and Chapter 4

UNIVERSITY OF WOLLONGONG

In reply please quote: HE12/443

28 January 2014

Professor Tony Okely
School of Education
Faculty of Social Sciences
University of Wollongong NSW 2522

Dear Professor Okely

Thank you for submitting the progress report. I am pleased to advise that **renewal** of the following Human Research Ethics application has been **approved**.

Ethics Number:	HE12/443
Project Title:	Patterns of sitting in childcare and developing ways to reduce sitting time
Researchers:	Professor Tony Okely, Professor John Reilly, Dr Rachel Jones, Ms Xanne Janssen, Ms Yvonne Ellis, Dr Steven Howard, Mrs Tamara Raso, Ms Hannah Goodhew, Ms Mylie Okely, Ms Anja GroBek, Ms Mahalia Royters, Ms Justine Harman, Ms Jacqueline Peperkamp, Ms Maddison Cooke, Jack Bird, Ms Jessica Tougher, Ms Kellie Ann Mahar
Date Approved:	28 January 2014
Renewed From:	6 February 2014
New Expiry Date:	5 February 2015

Please note that approvals are granted for a twelve month period. Further extension will be considered on receipt of a progress report prior to expiry date.

This certificate relates to the research protocol submitted in your original application and all approved amendments to date. Please remember that in addition to completing an annual report the Human Research Ethics Committee also requires that researchers immediately report:

- proposed changes to the protocol including changes to investigators involved
- serious or unexpected adverse effects on participants
- unforseen events that might affect continued ethical acceptability of the project.

Yours sincerely

Professor Kathleen Clapham
Chair, Social Sciences
Human Research Ethics Committee

Ethics Unit, Research Services Office
University of Wollongong NSW 2522 Australia
Telephone (02) 4221 3386 Facsimile (02) 4221 4338
Email: rso-ethics@uow.edu.au Web: www.uow.edu.au

Appendix B - Participant Information and consent form Chapter 3

University of Wollongong

Patterns of sitting in childcare and developing ways to reduce sitting time.

Information Sheet for Educators/Administration Staff

Dear

Full details about the project, it's purpose, the researchers involved and what is required of you, should you agree to be involved, are provided in this information sheet.

What is the purpose of this study?
The aim of this study is to conduct a number of focus groups with early childhood educators, administration staff and interested parents to discuss practical ways to reduce sitting time for toddlers and pre-schoolers whilst at childcare.

We have recently completed a study investigating the specific amount of time that toddlers and pre-schoolers spend sitting whilst at childcare. We found that on average children spent around half of the time sitting while at childcare. Excessive and prolonged amounts of sitting may be detrimental to the healthy growth of young children.

Given the potential harmful effects of long periods of sitting and the fact that around 80% of all young Australians spend some time in formal childcare each week, it is critical that strategies be developed and implemented to reduce the amount of total time toddlers and pre-schoolers spend sitting whilst in childcare given.

What we are asking you to do?
We are inviting you to participate in a one-off focus group. Each focus group will be approximately 1 hour in duration and will be facilitated at your early childcare service. You will be asked to join in a discussion on the prevalence of sitting time in early childhood services, as well as your own and to brainstorm practical ways to reduce sitting time for toddlers and pre-schoolers. Each focus group will also be asked to complete two daily schedules: the first will record a 'typical day' at childcare and include the times and activities undertaken as well as the posture that the majority of the children are in during each activity; the second schedule will be modified to promote more standing activities than sitting activities. This should take 30 minutes to complete within the hour workshop.
The focus group will take place on a prearranged date for each service.

What are the benefits and risks involved in this study?
This study will benefit your childcare service by providing information about the amount of time children spend sitting and the length of time they sit for throughout the day. The results from the study will be presented to the educators at your service and you, along with interested parents will have an opportunity to discuss the findings and ways in which current practices may be modified

to promote less time spent in sitting and thereby improve the health of the toddlers and pre-schoolers enrolled at your service.
There are no risks associated with this study.

Participation in the study
You are free to discontinue participation at any time. Discontinuation of your involvement will not jeopardise your current or future relationship your early childhood service or with the University of Wollongong.

What will happen to the information that you provide?
All information collected during this study will be kept strictly confidential and be stored in a locked office. Information provided during the focus groups maybe used in publications such as papers, conference presentations and grant applications, however your identity and that of your early childcare service will be kept strictly confidential.

Who is conducting the study?
- Professor Tony Okely, Professorial Fellow, Interdisciplinary Educational Research Institute, University of Wollongong
- Professor John Reilly, Visiting Professorial Fellow, Interdisciplinary Educational Research Institute, University of Wollongong
- Dr Rachel Jones, Research Fellow, Interdisciplinary Educational Research Institute, University of Wollongong
- Ms Xanne Janssen, Research Student, Interdisciplinary Educational Research Institute, University of Wollongong
- Ms Yvonne Ellis, Research Student, Interdisciplinary Educational Research Institute, University of Wollongong
- Mrs Tamara Raso, Project Manager, Interdisciplinary Educational Research Institute, University of Wollongong.
- Ms Maddison Cooke, Research Assistant, Interdisciplinary Educational Research Institute, University of Wollongong.

If you would like to participate in a focus group, please complete the attached consent form and return it to your Director.

Kind Regards,

Professor Tony Okely
Interdisciplinary Educational Research Institute
Faculty of Education
University of Wollongong
tokely@uow.edu.au
+61 2 42214641

If you have any questions regarding the study, please contact Professor Tony Okely on (02) 4221 4641. If you have any concerns or complaints regarding the way the research is or has been conducted, you can contact the Complaints Officer, Human Research Ethics Committee, University of Wollongong on (02) 4221 4457. OR by email on (rso-ethics@uow.edu.au).

Your co-operation in this project will be greatly appreciated.

University of Wollongong

Patterns of sitting in childcare and developing ways to reduce sitting time.

Consent form for Parents

Research conducted by Tony Okely, John Reilly, Rachel Jones, Steven Howard, Xanne Janssen, Tamara Raso, Yvonne Ellis, Maddison Cooke.

I have been given information about the study entitled: "*Patterns of sitting in childcare and developing ways to reduce sitting time*" and have had the opportunity to discuss the study with Professor Tony Okely.

I understand that if I consent to participating I will be asked to:

- Attend a one off-focus group at the childcare centre that my child enrolled in;
- Participate in discussion around the prevalence of sitting in childcare;
- Discuss strategies to reduce the amount of sitting time for toddlers and pre-schoolers at childcare.

I have been advised of the potential risks and burdens associated with this study. I understand that my participation is voluntary and that I am free to withdraw from the study at any time. Withdrawal from the study will not affect my relationship with the childcare service my child is enrolled in or with the University of Wollongong now or in the future. Furthermore, I understand that the information provided may be used in papers, conferences presentations or future grant applications.

If I have any enquires about the study, I can contact Tony Okely on 4221 4641 or if I have any concerns or complaints regarding the way the study is or has been conducted, I can contact the Complaints Officer, Human Research Ethics Committee, University of Wollongong on +61 2 42214457. OR by email on (rso-ethics@uow.edu.au).

By signing below I am indicating my consent to participate in this study as it has been described to me in the information sheet and in discussion with Tony Okely.

Your co-operation in this study will be greatly appreciated

University of Wollongong

CONSENT

I (your name) ___________________________________

agree to take part in the study entitled "*Patterns of sitting in childcare and developing ways to reduce sitting time*".

Parent Surname: ___________________________________

Parent Given name: ___________________________________

Address: ___________________________________

Postcode: ___________________________________

Phone: ___________________________________

Email: ____

Name of Childcare Centre: ___________________________________

Signature: ___________________________________

Date: ___________________________________

Appendix C - Information sheet and consent form Chapter 4

University of Wollongong

Patterns of sitting in childcare and developing ways to reduce sitting time.

Information Sheet for Educators/Administration Staff

Dear
Full details about the project, it's purpose, the researchers involved and what is required of you, should you agree to be involved, are provided in this information sheet.

What is the purpose of this study?
The aim of this study is to conduct a number of focus groups with early childhood educators, administration staff and interested parents to discuss practical ways to reduce sitting time for toddlers and pre-schoolers whilst at childcare.

We have recently completed a study investigating the specific amount of time that toddlers and pre-schoolers spend sitting whilst at childcare. We found that on average children spent around half of the time sitting while at childcare. Excessive and prolonged amounts of sitting may be detrimental to the healthy growth of young children.

Given the potential harmful effects of long periods of sitting and the fact that around 80% of all young Australians spend some time in formal childcare each week, it is critical that strategies be developed and implemented to reduce the amount of total time toddlers and pre-schoolers spend sitting whilst in childcare given.

What we are asking you to do?
We are inviting you to participate in a one-off focus group. Each focus group will be approximately 1 hour in duration and will be facilitated at your early childcare service. You will be asked to join in a discussion on the prevalence of sitting time in early childhood services, as well as your own and to brainstorm practical ways to reduce sitting time for toddlers and pre-schoolers. Each focus group will also be asked to complete two daily schedules: the first will record a 'typical day' at childcare and include the times and activities undertaken as well as the posture that the majority of the children are in during each activity; the second schedule will be modified to promote more standing activities than sitting activities. This should take 30 minutes to complete within the hour workshop.
The focus group will take place on a prearranged date for each service.

What are the benefits and risks involved in this study?
This study will benefit your childcare service by providing information about the amount of time children spend sitting and the length of time they sit for throughout the day. The results from the study will be presented to the educators at your service and you, along with interested parents will have an opportunity to discuss the findings and ways in which current practices may be modified

to promote less time spent in sitting and thereby improve the health of the toddlers and pre-schoolers enrolled at your service.
There are no risks associated with this study.

Participation in the study
You are free to discontinue participation at any time. Discontinuation of your involvement will not jeopardise your current or future relationship your early childhood service or with the University of Wollongong.

What will happen to the information that you provide?
All information collected during this study will be kept strictly confidential and be stored in a locked office. Information provided during the focus groups maybe used in publications such as papers, conference presentations and grant applications, however your identity and that of your early childcare service will be kept strictly confidential.

Who is conducting the study?
- Professor Tony Okely, Professorial Fellow, Interdisciplinary Educational Research Institute, University of Wollongong
- Professor John Reilly, Visiting Professorial Fellow, Interdisciplinary Educational Research Institute, University of Wollongong
- Dr Rachel Jones, Research Fellow, Interdisciplinary Educational Research Institute, University of Wollongong
- Ms Xanne Janssen, Research Student, Interdisciplinary Educational Research Institute, University of Wollongong
- Ms Yvonne Ellis, Research Student, Interdisciplinary Educational Research Institute, University of Wollongong
- Mrs Tamara Raso, Project Manager, Interdisciplinary Educational Research Institute, University of Wollongong.
- Ms Maddison Cooke, Research Assistant, Interdisciplinary Educational Research Institute, University of Wollongong.

If you would like to participate in a focus group, please complete the attached consent form and return it to your Director.

Kind Regards,

Professor Tony Okely
Interdisciplinary Educational Research Institute
Faculty of Education
University of Wollongong
tokely@uow.edu.au
+61 2 42214641

If you have any questions regarding the study, please contact Professor Tony Okely on (02) 4221 4641. If you have any concerns or complaints regarding the way the research is or has been conducted, you can contact the Complaints Officer, Human Research Ethics Committee, University of Wollongong on (02) 4221 4457. OR by email on (rso-ethics@uow.edu.au).

Your co-operation in this project will be greatly appreciated.

University of Wollongong

Patterns of sitting in childcare and developing ways to reduce sitting time.

Consent form for Educators/Administration Staff

Research conducted by Tony Okely, John Reilly, Rachel Jones, Steven Howard, Xanne Janssen, Tamara Raso, Yvonne Ellis, Maddsion Cooke.

*I have been given information about the study entitled: "*Patterns of sitting in childcare and developing ways to reduce sitting time*" and have had the opportunity to discuss the study with Professor Tony Okely*

I understand that if I consent to participating I will be asked to:

- Attend a one off-focus group;
- Participate in discussion around the prevalence of sitting in childcare;
- Discuss strategies to reduce the amount of sitting time for toddlers and pre-schoolers at childcare.

I have been advised of the potential risks and burdens associated with this study. I understand that my participation is voluntary and that I am free to withdraw from the study at any time. Withdrawal from the study will not affect my relationship with my childcare service or with the University of Wollongong now or in the future. Furthermore, I understand that the information provided may be used in papers, conferences presentations or future grant applications.

If I have any enquires about the study, I can contact Tony Okely on 4221 4641 or if I have any concerns or complaints regarding the way the study is or has been conducted, I can contact the Complaints Officer, Human Research Ethics Committee, University of Wollongong on +61 2 42214457. Or by email on rso-ethics@uow.edu.au

By signing below I am indicating my consent to participate in this study as it has been described to me in the information sheet and in discussion with Tony Okely.

Your co-operation in this study will be greatly appreciated

University of Wollongong

CONSENT

I (your name) ________________________________ agree to take part in the study entitled "*Patterns of sitting in childcare and developing ways to reduce sitting time*".

Surname: ________________________________

Given name: ________________________________

Address: ________________________________

Postcode: ________________________________

Phone: ________________________________

Name of Childcare Centre: ________________________________

Signature: ________________________________

Date: ________________________________

Appendix D – Ethics approval Chapter 5

Health
Illawarra Shoalhaven
Local Health District

Research Directorate
Telephone: 02 4253 4800
Facsimile: 02 4253 4803

TRIM NO: DT13/69132
Ref: HE13/406
APPROVAL

Professor Tony Okely
School of Education
Faculty of Social Sciences
Building 22
UNIVERSITY OF WOLLONGONG NSW 2522

Dear Professor Okely

HREC project number: HE13/406
Project title: Acute effects of a "reduced-sitting pre-school day" on energy expenditure, musculoskeletal health, and cognitive development in pre-schoolers: a whole room calorimeter study

Thank you for submitting a Site-Specific Assessment Form for Low and Negligible Risk Research application for authorisation of the above project. I am pleased to inform you that authorisation has been granted for this study to take place at the following sites:

- Physiotherapy Department – Wollongong Hospital
- Physiotherapy Department – David Berry Hospital

This approval is valid with a current Human Research Ethics Committee approval.

The following conditions apply to this research project. These are additional to those conditions imposed by the Human Research Ethics Committee that granted ethical approval:

1. Proposed amendments to the research protocol or conduct of the research which may affect the ethical acceptability of the project, and which are submitted to the lead HREC for review, are copied to the research governance officer;
2. Proposed amendments to the research protocol or conduct of the research which may affect the ongoing site acceptability of the project, are to be submitted to the research governance officer.

Yours faithfully

KRISTY VARDANEGA
Research Governance Officer

21 November 2013

c.c. Anne Smith, HOD – Physiotherapy

Research Directorate
Level 8, Block C, Wollongong Hospital
(LMB 8808, SCMC NSW 2521)

UNIVERSITY OF WOLLONGONG

In reply please quote HE13/406

31 October 2013

Professor Tony Okely
School of Education
Faculty of Social Sciences
University of Wollongong NSW 2522

Dear Professor Okely

Thank you for your correspondence of 30 October 2013 responding to the HREC review of the application below. I am pleased to advise that the application has been **approved**.

Ethics Number:	HE13/406
Au RED Number:	LNR/13/WGONG/146
Project Title:	Acute effects of a "reduced-sitting pre-school day" on energy expenditure, musculoskeletal health, and cognitive development in pre-schoolers: a whole room calorimeter study
Name of Researchers:	Professor Anthony Okely, Professor Stewart Trost, Dr Diane Harland, Mrs Samantha Stephens, Mrs Lyndel Hewitt, Mrs Joanne Morrell, Dr Steven Howard, Mrs Tamara Raso, Mrs Melinda Smith
Sites/CIs reviewed:	University of Wollongong, Calorimeter Room, Building 41.302
Documents Reviewed/Approved:	1. Original Ethics UOW Application Form 2. Low or Negligible Risk (LNR) NSW Health Application Form 3. Consent Form for parents/guardians on behalf of their child *(Version 2: 30/10/13)* 4. Draft Preschool Day in the Calorimeter Room *(Timetable – Version 1: 23/10/13)* 5. Information Sheet for Parents *(Version 1: 3/9/13)* 6. Introduction for Parents *Validity of energy expenditure equations in pre-school children: A whole body calorimeter study* 7. Activity Monitors Information Sheet *(Version 1: 3/9/13)* 8. Standing Preschools Project Activity Monitor Log *(Version 1: 3/9/13)*
Approval Date:	31 October 2013
Expiry Date:	30 October 2014

The University of Wollongong/ISLHD Humanities, Social Science and Behavioural HREC is constituted and functions in accordance with the NHMRC *National Statement on Ethical Conduct in Human Research*. The HREC has reviewed the research proposal for compliance with the *National Statement* and approval of this project is conditional upon your continuing compliance with this document.

Ethics Unit, Research Services Office
University of Wollongong NSW 2522 Australia
Telephone (02) 4221 3386 Facsimile (02) 4221 4338
Email: rso-ethics@uow.edu.au Web: www.uow.edu.au

A condition of approval by the HREC is the submission of a progress report annually and a final report on completion of your project. The progress report template is available at http://www.uow.edu.au/research/rso/ethics/UOW009385.html. This report must be completed, signed by the appropriate Head of School and returned to the Research Services Office prior to the expiry date.

As evidence of continuing compliance, the Human Research Ethics Committee also requires that researchers immediately report:

- proposed changes to the protocol including changes to investigators involved
- serious or unexpected adverse effects on participants
- unforseen events that might affect continued ethical acceptability of the project.

Please note that approvals are granted for a twelve month period. Further extension will be considered on receipt of a progress report prior to expiry date.

Please note that Governance approval is required for research within NSW Ministry of Health. Refer to: https://ethicsform.org/Au/SignIn.aspx

A copy of this letter has been forwarded to the ISLHD Research Governance Officer. For further information regarding the SSA in the ISLHD, contact:

Research Governance Officer
Illawarra Shoalhaven Local Health District
Research Directorate
Wollongong Hospital
Block C, Level 8
P: 02 4253 4876
E: Kristy.Vardenega@SESIAHS.HEALTH.NSW.GOV.AU

If you have any queries regarding the HREC review process, please contact the Ethics Unit on phone 4221 3386 or email rso-ethics@uow.edu.au.

Yours sincerely

Professor Kathleen Clapham
Chair, Social Sciences
Human Research Ethics Committee

cc: Governance Officer, Research Directorate, ISLHD

Appendix E - Information and consent form Chapter 5

University of Wollongong

NSW GOVERNMENT Health Illawarra Shoalhaven Local Health District

Standing Pre-schools Project

Short-term effects of a "reduced-sitting pre-school day" on energy expenditure, musculoskeletal health, and cognitive development in pre-schoolers: a whole room calorimeter study.

Information Sheet for Parents

Dear Parent

Full details about the project, it's purpose, the researchers involved and what is required of your child, should you agree for your child to be involved, are provided in this information sheet.

What is the purpose of this study?
The aim of this study is to assess the acute effects of a "reduced-sitting pre-school day" on energy expenditure, musculoskeletal health, and cognitive development in pre-schoolers', using the whole room calorimeter. The calorimeter is a room around the size of a child's bedroom which measures the oxygen consumption and carbon dioxide production of the person inside. From these measurements we are able to accurately measure energy expenditure.

Currently, very little is known about the time young children spend sitting whilst at childcare and the patterns of their sitting. However, what is known is that long periods of sitting maybe harmful for the health, growth and development of young children. Given the potential harmful effects of prolonged periods of sitting and the fact that around 80% of all young Australians spend some time in formal childcare each week, it is important to understand how much more energy is expended if a child sits for less total time during a typical pre-school day.

We are asking for your assistance in furthering our research in this area, by allowing your child to participate in this study.
Your child must be 4 or 5 years old to participate in this study. If your child is currently 3, but turning 4 before data collection begins then you may register your child to participate while they are still 3.

Significance and Innovation
This study plans to address the high levels of sitting found among pre-schoolers during their time at child care, which has the potential to substantially improve the health and

developmental outcomes of the children. Our research team is currently working with pre-school staff to identify ways to modify the pre-school environment and policies to reduce by half the amount of time spent sedentary (sitting) during a pre-school day. This study is being funded by a Illawarra Health and Medical Research Institute Small Grant.

What we are asking your child to do?
We are asking your child to visit the Calorimeter room at the University of Wollongong on three occasions. During the first visit they will become familiar with the calorimeter room and complete some initial measurements. On the remaining two visits the child will participate in a half day mock childcare routine where they will be observed and their energy expenditure will be measured. The child will be asked to wear some physical activity monitors during their time in the Calorimeter room. Further details of these monitors are outlined below in the details of the visits. During their time inside the Calorimeter room the child will be in the room on their own, but still in constant visual and verbal contact with their parent/guardian and the qualified childhood educator and research students. They will stay inside the room for approximately 2 to 2.5 hours, the equivalent of half a day in childcare

Your child's height and weight will be measured and musculoskeletal and executive function assessments will be conducted prior to entering and immediately upon leaving the calorimeter room. The Child will be asked to wear two small lightweight monitors after visits two and three, for 48 hours after each visit. The Parent/Guardian of the child participating will be asked to complete a Monitor Log that tracks when the child is wearing these monitors.

Details of Visits:
Visit 1 – Initial familiarisation with calorimeter room and a discussion with parents and children to start the process of consent. The child will take home an information book which parents will read to them several times to familiarise them both with the study.

Visit 2 – (typical pre-school day-50% of time sitting). Participants will arrive at around 8.30am after having eaten a standardised breakfast at 7am. Musculoskeletal, height and weight, and executive function assessments will be conducted prior to entering and immediately upon leaving the calorimeter. A standard morning tea will be consumed around 1.5 hrs after entering the calorimeter and lunch will be provided at the completion of the protocol (after 3 hrs in the calorimeter). Participants will then spend 50% of their time in the calorimeter sitting, undertaking tasks that they normally would as part of a typical day at pre-school. The parent will be able to view the child in the Calorimeter at all times if desired. The child will be constantly supervised and in contact with a trained qualified Childcare educator, and a research student from the University of Wollongong.

Visit 3 – (modified pre-school day-25% of time sitting). This will be identical to Visit 2 except that participants will sit for 50% less time and replace this with 50% more time spent in light-intensity activity (such as standing) based on the modifications suggested by child care staff and tested by our paediatric physiotherapists. Musculoskeletal, height and weight, and executive function assessments will be conducted prior to entering and immediately upon leaving the calorimeter. The parent will be able to view the child in the Calorimeter at all times if desired. The child will be constantly supervised and in contact with a trained qualified Childcare educator, and a research student from the University of Wollongong.

Before entering the calorimeter on Visits 2 and 3, your child will be fitted with an Actigraph accelerometer on each wrist and both hips, a Sensewear device around their upper arm and a GENEActiv (accelerometer) on each wrist and both hips. Your child will also be asked to wear a small lightweight activity monitor (called an activPAL). The activPal activity monitor is worn on the upper thigh being attached to the child's thigh using a dual layer of Hydro Gel (which is similar to a bandaid) as recommended by the manufacturer. This activity monitor allows us to measure the amount of time sitting as well as different postures.

Your child will also be fitted with two small devices that will be used to assess their posture, using video footage of their time in the room. This will be a small hair clip and belt around their waist.

Your child will furthermore be fitted with an EEG measurement headband, which will measure brain electrical activity from one location on the forehead. This measurement will occur whilst completing the following tasks:

1. Eyes open – the participant is required to sit with their eyes open, directed towards a fixation cross, for 3 minutes.
2. Eyes closed- the participant is required to sit with their eyes closed for 3 minutes.
3. Executive function tests after visit 2 and 3

From these measurements we want to see if there are any differences in EEG data when completing the Executive Function tests after a 'typical day' and a 'modified day'.

Participants will be free to leave the calorimeter at any time, or remove the Physical Activity Monitors if they cause any distress. All measurements will be in the presence of a research assistant (an early childhood trained educator who can observe and communicate with the participant at all times via an external window and intercom).

Visits 2 and 3 will be randomly allocated to each child so there is a chance your child could do visit 3 prior to visit 2.

Visit 2 and 3 will last 4 hours, this includes the assessments before and after entering the calorimeter room.

As there is a possibility that children may compensate for sitting less and engaging in more light-intensity PA by being less active afterwards, we will ask them to wear an Actigraph and

a Sensewear mini arm band whilst in the calorimeter, and for 48 hours afterwards. The Sensewear Mini combines accelerometry with four additional physiological sensors (heat flux sensor, galvanic skin response, skin temperature, and a near-body ambient temperature) and will be used to assess energy expenditure over the 48 hour period immediately following Visits 2 and 3. To measure if participants compensate for less sitting by increasing their energy intake, we will ask participants to complete 2, 24hr food diaries over the same 48 hr period.

The Parent or Guardian of the Participant will be asked to fill in a one-page accelerometer log that provides information about when the monitor was worn or not worn (eg removed for bathing) during the 48-hour period immediately following Visits 2 and 3. An information sheet about these monitors will be provided.

Your child will be recorded on video while performing the activities in the calorimeter. The video recording helps us to analyze their posture while standing. No one else other than the researchers involved in this study will have access to the video recording and it will be stored securely in a locked office.

What are the benefits and risks involved in this study?
This study plans to address the high levels of sitting found among pre-schoolers during their time at child care which has the potential to substantially improve the health and developmental outcomes of the children.
There are minimal risks associated with this study. Your child will be supervised by the researchers at all times. Your child can alert the researcher by pressing a button. In addition, the intercom will be left on at all times so that your child can be heard outside the calorimeter at all times. Your child will be able to see the educator and research assistant at all times and will be able to exit the calorimeter if they wish.

As we will be providing your child with a healthy snack while they are in the Calorimeter room we ask you to provide any food or contact allergy information for your child on the consent form. This also includes any allergy to wheat and Play-Doh that your child will be playing with.

Some of the Executive Function assessments will use coloured cards to test the child. If your child is colour blind please indicate this on the consent form.

EEG measurement and recording is 100% safe and pain-free. EEG recording is a non-invasive and safe way to view and record brain electrical activity. It involves fitting an EEG measurement headband, a procedure that takes 10-30 seconds. Note that this form of EEG measurement allows identification of atypical brain functioning at an individual level, and parents will be informed of this if identified by the research, and confirmed by the research supervisor, with referral to a suitable medical professional (e.g. neurologist).

Participation in the study
You and your child are free to discontinue participation at any time. Discontinuation of your or your child's involvement will not jeopardise your or your child's current or future relationship your early childhood service or with the University of Wollongong.

What will happen to the information that you provide?
All information collected during this study will be kept strictly confidential and be stored in a locked office. Data from the activity monitors maybe used in publications such as papers, conference presentations and grant applications, however your identity, your child's identity and that of your early childcare service will be kept strictly confidential.

Who is conducting the study?

- Professor Tony Okely, School of Education, University of Wollongong.

- Professor Stewart Trost, School of Human Movement Studies, University of Queensland
- Dr Diane Harland, School of Health Sciences, University of Wollongong
- Lyndel Hewitt, Paediatric Physiotherapist, Wollongong Hospital
- Samantha Stevens, Paediatric Physiotherapist, Wollongong Hospital
- Joanne Morrell, Paediatric Physiotherapist, Wollongong Hospital
- Dr. Steven Howard, School of Education, University of Wollongong.
- Ms Yvonne Ellis, PHD Student, School of Education, University of Wollongong.
- Mrs Tamara Raso, School of Education, University of Wollongong.
- Mrs Melinda Smith, School of Education, University of Wollongong.

If you are happy for your child to participate in this study, please complete the attached consent form and return it via email (traso@uow.edu.au) or using the reply paid envelope to Tamara Raso, School of Education, University of Wollongong.

Kind Regards,

Professor Tony Okely
Interdisciplinary Educational Research Institute
School of Education, University of Wollongong
tokely@uow.edu.au
+61 2 4221 4641

If you have any questions regarding the study, please contact Prof Tony Okely on (02) 4221 4641. If you have any concerns or complaints regarding the way the research is or has been conducted, you can contact the Complaints Officer, Human Research Ethics Committee, University of Wollongong on (02) 4221 4457 or by email (rso-ethics@uow.edu.au).

Your co-operation in this project will be greatly appreciated.

University of Wollongong

Health
Illawarra Shoalhaven
Local Health District

Standing Pre-schools Project

Acute effects of a "reduced-sitting pre-school day" on energy expenditure, musculoskeletal health, and cognitive development in pre-schoolers: a whole room calorimeter study.

Consent form for parents/guardians on behalf of their child

I have been given information about the study entitled: "*Acute effects of a "reduced-sitting pre-school day on energy expenditure, musculoskeletal health, and cognitive development in pre-schoolers: a whole room calorimeter study*".

And have had the opportunity to discuss the study with Professor Tony Okely.

I understand that if I consent for my child to participate they will be asked to:

- Participate in three visits to the University of Wollongong. Using the whole room calorimeter, they will be assessed on the acute effects of a 'reduced-sitting pre-school day' on their energy expenditure.
- Participate in Musculoskeletal, height and weight, and executive function assessments, which will be conducted prior to entering and immediately upon leaving the calorimeter room on visits two and three.
- Wear 2 monitors for the 48 hour period after visits two and three in the calorimeter room. During this time the Parent/Guardian is asked to complete a monitor log.
- During their time in the calorimeter room wear physical activity assessment monitors and an EEG measurement headband

I have been advised of the potential risks and burdens associated with this study. I understand that my participation and my child's participation is voluntary and that I and/or my child are free to withdraw from the study at any time. Withdrawal from the study will not affect my relationship or that of my child's, with our childcare service or with the University of Wollongong now or in the future. Furthermore, I understand that the information provided may be used in journal articles, conferences presentations or future grant applications.

If I have any enquires about the study, I can contact Tony Okely on 4221 4641 or if I have any concerns or complaints regarding the way the study is or has been conducted, I can contact the Complaints Officer, Human Research Ethics Committee, University of Wollongong on +61 2 42214457. Or by email on (rso-ethics@uow.edu.au).

By signing below I am indicating my consent for my child to participate in this study as it has been described to me in the information sheet and in discussion with Tony Okely.

To organise return of the monitors please contact Yvonne Ellis on email yge019@uowmail.edu.au or phone on 4221 5486
Or Tamara Raso on email: traso@uow.edu.au or phone 4221 5517.

Your co-operation in this study will be greatly appreciated.

University of Wollongong

CONSENT

I (your name) ________________________________

agree for my child (**child's full name**)

____

to take part in the study entitled *Standing Pre-schools Project:*

"*Acute effects of a "reduced-sitting pre-school day on energy expenditure, musculoskeletal health, and cognitive development in pre-schoolers: a whole room calorimeter study*".

☐ Please tick to indicate Parent/Guardian consent for child participant to attend 3 sessions in the Calorimeter Room, at the University of Wollongong.

Parent Surname: ________________________________

Parent Given name: ________________________________

Child's Date of Birth: ___________________________(dd/mm/yyyy)

Sex of the Child: ________________________________(male/female)

Address: ____

Postcode: ________________________________

Home Phone: ________________________________

Mobile Phone: ________________________________

Email: ____

Please list any food or contact allergy advice for your child:

Is your child Colour Blind? **Y / N** Please circle.

Signature: ________________________________

Date: ________________________________

Name of Childcare Centre:____

(If recruited from Childcare Centre)

OR

Method of Recruitment: ____

(Eg University of Wollongong Staff email).

Appendix F - Information booklet Calorimeter study Chapter 6

University of Wollongong

NSW GOVERNMENT | Health Illawarra Shoalhaven Local Health District

Standing Pre-schools Project

Short-term effects of a "reduced-sitting pre-school day" on energy expenditure, musculoskeletal health, and cognitive development in pre-schoolers:
a whole room calorimeter study

What is the purpose of this study?

The aim of this study is to assess the acute effects of a "reduced-sitting pre-school day" on energy expenditure, musculoskeletal health, and cognitive development in pre-schoolers', using the whole room calorimeter. The calorimeter is a room around the size of a child's bedroom which measures the oxygen consumption and carbon dioxide production of the person inside. From these measurements we are able to accurately measure energy expenditure.

This booklet is meant as an information brochure for you and your child. The kind of activities we will ask your child to do during the three hours in the calorimeter will be explained on the following pages and are described in simple language so that your child is able to understand.

During the first visit they will become familiar with the calorimeter room and complete some initial measurements. On the remaining two visits the child will participate in a half day mock childcare routine where they will be observed and their energy expenditure will be measured. On these visits we will take a few more measurements and play some memory games with them. Each visit will last 3 to 3.5 hours – the equivalent of half a day in childcare.

You will be in the room next to where your child will be. There is a large window between these two rooms, so you and your child will be able to see each other throughout the testing period.

Once the room has been closed it must remain closed for efficient data collection. The door can only be opened if the child wants to leave, ending the session.

Both rooms have a usable telephone. You can call your child at any time and he/she will also be shown how to use the telephone so they can call you any time. In addition, there is an intercom which will be switched on the entire time. We will be able to hear your child and your child will be able to hear us the whole time.

The door of the calorimeter will be closed with two door-handles. It will be possible for your child to open the door from the inside as well as it being opened from the outside of the room. Before we close the handles, we will check that your child is able to open the door and the handles independently. During the testing procedure there will be a few people present besides yourself – research students and a qualified Early Childhood Educator. If your child wants to leave the room or if you think that it is necessary to discontinue the study prematurely, he/she will be able to leave the room immediately. Your child will be able to use the toilet in the room if required.

This is the whole room calorimeter.

It is a room almost as big as the size of your bedroom. Don't you think it looks like a submarine? You will be in here **on your own** and your mum and/ or dad will be in the room next to you. You will be able see each other through the window!

You are going to do lots of fun activities and games in the room. In the next chapters we are going to explain what you are going to do.

Visit 1

On this visit you will come and have a look around the room and we will take a few measurements. We want to know how big you are. What is your height and your weight? We can measure it using a scale and a special ruler – it's really long!!

This is Mikayla.
Here we are measuring the amount of water in her body

We will show you some little monitors that you will be wearing each time you visit the room.
To measure how active you are, you will be wearing 10 motion-sensors, which will be attached on your arms, hips and leg. We will also ask you to wear a small hair clip or belt so we can see how your body moves when you are standing up.

Here is Mikayla again. She is wearing the motion sensors.

Visits 2 and 3

Visit 2 will be just like a morning at your childcare. You will play lots of fun games while you are in the room.
Visit 3 will be almost the same, but with a little more moving around. We will play lots of fun games and take a few more measurements at each visit. We will also play some fun memory games before you go into the room, and when you come out.
You will have a yummy morning tea during your time in the room, and when we are finished you will be given a healthy lunch.

These are some of the fun things you will be doing while in the room

- There is a phone in the room. While you are in there you can phone the other room, where your mum or dad will be. We will show you how the phone works.

- Reading books with a CD. There will be a special music player in the submarine which you can use. On the cd you will hear a story read aloud. We will ask you to follow along in the book by turning the page when you hear the special noise.

This is Sam. He is reading the story about giraffes can't dance.

We have some great games to play while listening to the story.

- Colouring and drawing

  We've got a special desk for you. On this desk are lots of different colouring pictures for you. You could even colour in a picture to give your mum or dad when you're finished.

Some times you will be sitting at this desk and sometimes we will ask you to stand up while you are drawing or doing craft.

- ❖ Playing with toys
  Playing with toys is fun and we want you to have lots of fun during your time in the submarine. You will be able to choose some toys to play with such as Lego, Knex, dolls, and play-doh. We will also ask you to make a special puzzleon the table and then on the wall.

- ❖ Drawing on a whiteboard
  There are a lot of sea creatures swimming in the sea. Can you see them through the small round windows above the whiteboard? We would like you to draw a picture of the sea creatures on the whiteboard?

Here is Sam playing on a Guiro.

- ❖ Playing a musical instrument

  Can you play a musical instrument and make a loud sound? There will be some different musical instruments in the room. Do you know what a djembe is, a wooden musical frog and zebra drum are? You can have a turn at playing some instruments.

- ❖ Minigolf.
  Do you know minigolf?

We would like you to try and get the ball in the hole.

- ❖ Domestic chores. We've got some laundry to hang out from the toy dolls and teddies. Could you put it on the clothes line for us? And could you show us how to set the table?

- ❖ Kinder Aerobics, dancing and Yoga

You will be told and shown how to do the exercises and we will play some fun music.

Here is Sam dancing.

- Basketball
  Do you want to play basketball? It is a bit smaller then you might be used to. That's because there isn't much space in a submarine, but remember that it is still important to keep fit!

- Animal walks. We will play some balance games and move like different animals.
  We would like to see if you can gallop like a horse or jump like a kangaroo?

- Hitting a balloon in the air
  Can you try to keep the balloon in the air by hitting it with your hand

and what about 2 balloons?

And lots more fun games like these…….

After your second and third visit we will ask you to wear some of your special monitors home with you, and wear them for 2 days. Your Mum, Dad or the person who looks after you will be asked to fill in a diary when you wear them or not. They have to write down when you take the monitors off, like when you have a bath or go swimming.

We also ask Mum, Dad or the person looking after you, to write down how much you eat and drink over this time to see how hungry you are after your visits to us.

When you finish your third visit you will get a special certificate and a small gift for all your hard work.

We're looking forward to seeing you! ☺

If you have any questions, you can ask your parents to call us.

Yvonne Ellis (02) 4221 5486

Tamara Raso (02) 4221 5517 or

Tony Okely (02) 4221 4641.

If you have any questions regarding the study, please contact Prof Tony Okely on (02) 4221 4641. If you have any concerns or complaints regarding the way the research is or has been conducted, you can contact the Complaints Officer, Human Research Ethics Committee, University of Wollongong on (02) 4221 4457 or by email (rso-ethics@uow.edu.au).

INTERDISCIPLINARY EDUCATIONAL RESEARCH INSTITUTE

Appendix G - Protocol Typical and Reduced Pre-school Day Chapter 5

Date: Name: Visit: 2 / 3 TYPICAL Pre-school Day: 50% Sitting Time

	Activities	Min	Notes
9.00	• Welcome parents and participant at the reception of IHMRI • Child has breakfast • Walk to calorimeter room • Toileting (5 min) • Fitting of monitors (10 min)	30	
9.30	• Entrance into the calorimeter room. **This needs to be done very quickly!** • **Let child sit down for 4 min, talk about the room and all the activities the child is able to do.** • Initiate monitors with Jump! • Welcome song 'I wonder what your name is' standing and clapping on the mat. • 'Simon says' sitting on the mat	2 standing 2 sitting	
9.34	**Physical activity stretches on iPad**	3 standing	
9.37	**Free play** Sitting activities: • Lego/duplo/zoobs/play dough **sitting** at table or on mat • Craft/Drawing/puzzle **sitting** at the table Standing activities • Drawing white board • Other activities at the table (drawing/puzzle/kinetic sand) *NOTE: If this is the second visit try to do similar standing activities.* Back-up standing activities: • Roll the dice • Treasure hunt	20 min 5- sitting 15- standing	
9.57	**Five minute warning** is given to the child for end of free playtime. • Educator will encourage the child to tidy up the room. This can lead to cleaning the room in a fun way. - Pack away equipment - Shake both mats - Dust everything off	5 – standing	-

	• Child chooses 3 books (Rumble in the Jungle, Little Rabbit Fufu and the book with the pan and sausages) from the basket.		
10.02	**Story time** • Child picks up 3 books from the basket and puts it on the mat. • Open the book Rumble in the Jungle, child switch pages along with the music. • ''Little Rabbit Fufu'' music will be played from iPad. Child sits on mat ''Sausages in the Pan'', when the child has to throw it needs to stand up. *NOTE: If child does not like to read the books again the same visit, child can pick other book.*	15 – sitting	
10.17	**Toileting and Hand washing** if required. **Monitor check**. **Drink water**	2 standing	-
10.19	**Morning tea** • Child will sit at the table • Morning tea to be supplied in a paper bag and place on the table. • Child will place all rubbish back in the paper bag supplied and leave it on the table. • Look at morning tea placement so they don't have to move. *NOTE: Content of morning tea needs to be similar to the visit before!*	8 sitting	-
10.27	**- Hands washing** **- Child picks up 2 bags with music instruments and one with animals before sitting on the mat.**	1 standing	-
10.28	**Music and Movement** • Exploration of musical instruments sitting on mat - Show the child the pictures of music instruments that are in the red folder, the child will need to play these instruments that are shown on the picture. • Animal bag, child picks an animal out of the bag and sings a song about it.	10 sitting	
	Child hangs up the bags, picks up feely bag and place it on table	1 standing	
10.38	**Drawing/feely bag** • Drawing/ mask/crafts sitting at the table • Feely bag: child to place their hand inside a bag and feel the object within while sitting on chair. They can then try to describe or guess what the item may be without looking at them. **Back-up activities** • Drawing book	10 sitting	
10.48	**Play ballgames** • Put Mats away • Bounce the ball with two hands/left/right hand • Try to throw the ball in the hoop as many times • Hitting balloons in the air with one or two hands.	10 standing	-
10.58	**Language and Literacy** - Magnets, Mel will tell the child where to stick the magnets on in the room.	10 sitting	

	- Drawing, writing of letters (their name), discussion of numbers (their age, no of siblings/cousins) sitting at the table. - Shapes, Mel will tell the child what kind of shape to draw Back up: - Colouring in - Crafts (mask)		
11.08	**Kinder aerobics** • Jumping activities, jump on different pictures • Involve the child in a game of modified Hopscotch (jumping or hopping in the hopscotch squares). • Dance on two songs (Hokey Pokey and head shoulders knees and toes, tooty ta song) • Movement Dice → child throws the dice	10 – standing	-
11.18	**Lego** on easel	5 sitting	-
11.23	**Clothes Line:** hang t-shirts on clothes line	5 standing	-
11.28	**Kinetic sand** (sitting at the table)	5 sitting	-
11.33	**Free play** • The child is free to choose an activity to take part in. <u>Sitting activities:</u> • Lego/duplo/zoob/playdough sitting on the mat • Craft/Drawing/puzzle sitting at the table <u>Standing activities</u> • Use coloured cards with pictures of equipment that child needs to find (if child is bored). • Standing drawing on whiteboard • Use of magnets *NOTE: If this is the second visit try to do similar standing activities.* <u>Back-up standing activities:</u> - Roll the dice - Treasure hunt	15 min 5 sitting 10 standing	
11.49	**Gross Motor Skills** • Quoits • Throwing • Put put golf	10 standing	
12.00	**Pack away**	1 standing	-

12.00	End of Calorimeter room session. Child to leave the room when instructed. Toileting and hand washing routine will be implemented.		
TOTAL		**150 min** **- 75 min sitting** **- 75 min standing/ stepping**	
	- Toileting and hand washing routine will be implemented. - Walk to IHMRI examination room - Take off monitors (5 min) - Executive function testing (iPad) (20 min) - Musculoskeletal assessments (Strength, flexibility, balance) (15 min) - Provide the lunch (30 min)	90 min	
13.30	END		

Date: Name: Visit 2 / 3 Reduced Pre-school Day: 25% Sitting Time

	Activities	Min	Notes
9.00am	• Welcome parents and participant at the reception of IHMRI • Breakfast • Toileting • Walk to Calorimeter Room • Fitting of monitors	60	
9.30	• Entrance into the calorimeter room with morning tea. **This needs to be done very quickly!** • First 4 minutes free activity • Initiate monitors with Jump! • Welcome song 'I wonder what your name is' standing and clapping on the mat. • 'Simon says'	4 - standing	
9.34	**Physical activity stretches on iPad**	3 - standing	
9.37	**Free play** Table activities: • Lego/duplo/zoobs/play dough **sitting** at table/mat • Craft/Drawing/puzzle **standing** at the table *NOTE: If this is the second visit try to do similar standing activities.* Other: • Drawing white board • Roll the dice • Treasure hunt	20 min 5 sitting 15 standing	
9.57	**Five minute warning** is given to the child for end of free playtime. • Educator will encourage the child to tidy up the room. - Pack away equipment - Shake both mats - Dust everything off • Child chooses 3 books (Rumble in the Jungle, Little Rabbit Foofoo and the book with the pan and sausages) from the basket.	5 – standing/moving	
10.02	**Story time** • Child picks up 3 books from the basket and puts it on the mat. • Open the book Rumble in the Jungle, child switch pages along with the music. • ''Little Rabbit Fufu'' music will be played from iPad. Try to break up the sitting by using a ''hammer'' (duster) and try to hit the ''worms/mice etc…'' • Child sits on mat ''Sausages in the Pan'', when the child has to throw it needs to stand up. *NOTE: If child does not like to read the books again the same visit, child can pick other book.*	15 min 12 sitting 3 standing	
10.17	**Toileting and Hand washing** if required, **Monitor check**, **Drink water**	2 standing	
10.19	**Morning tea** • Child will be asked to retrieve their morning tea from a box within the room. • A water bottle will also be provided and collected by the child from another place in the room. • The child will sit at the table or on the mat • The child will be asked to take rubbish items to the bin once they have finished their morning tea.	8 min 7 sitting 1 standing	

	• Look at bin placement. *NOTE: Morning tea needs to be similar to the visit before!*		
10.27	**Hands washing**	1 standing	
10.28	**Music and Movement** • Child picks up 2 bags, one with music instruments and one with animals and place these on the table. 1. Exploration of musical instruments standing at standing table. - Show the child the pictures of music instruments that are in the red folder, the child will need to play these instruments that are shown on the picture. 2. Animal bag, child picks an animal out of the bag and sings a song about it. • Child hangs the bags back and pick up feely bag	10 standing/moving	
10.38	**Drawing/feely bag** • Drawing/ mask/crafts at standing desk • Sitting on chair → Feely bag: child to place their hand inside a bag and feel the object within while sitting on a chair. They can then try to describe or guess what the item may be without looking at them. **Back-up activities** Hide and seek. Have various items hidden within the room; show the child a picture of the item, which is to be found.	5 standing 5 sitting	
10.48	**Play basketball/ballgames** • Put Mats away • Bounce the ball with two hands/left/right hand • Try to throw the ball in the hoop as many times • Hitting balloons in the air with one or two hands.	10 standing/moving	
10.58	**Language and Literacy** • Magnets: tell child where to stick magnets in the room • Drawing, writing of letters (their name), discussion of numbers (their age, no of siblings/cousins) standing at the standing table/white board. • Drawing sitting at the table **Back up:** - Colouring in - Crafts (mask)	10 standing 5 sitting	
11.13	**Kinder aerobics** • Jumping activities, jump on different pictures. • Involve the child in a game of modified Hopscotch (jumping or hopping in the hopscotch squares). • Dance on two songs (Hokey Pokey and head shoulders knees and toes) • Movement Dice → child throws the dice	10 – standing/moving	
11.23	**Lego** on easel	15 standing	
	Clothes Line: hang t-shirts on clothes line **Extension Activity:** - standing at table		
	Kinetic sand (Standing at the table)		
11.38	**Free play** <u>Sitting activities:</u>	<u>15 min</u>	

	• Lego/duplo/zoob/playdough sitting on the mat • Craft/Drawing/puzzle sitting at the table <u>Standing activities</u> • Use coloured cards with pictures of equipment that child needs to find (if child is bored). • Drawing on whiteboard *NOTE: If this is the second visit try to do similar standing activities.* <u>Back-up activities:</u> - Roll the dice - Treasure hunt	5 sitting 10 standing	
11.53	**Gross motor skills activities** • Put/put golf • Quoits • Throwing puppets in baskets • Balancing Activity using animals (Turtle)	7 standing/moving	
12.00	**Pack away**		
12.08	End of Calorimeter room session. Child to leave the room when instructed.		
12.15		**150 min** **- 39 min sitting** **- 111 min standing/ stepping**	
TOTAL	- Toileting and hand washing routine will be implemented. - Walk to IHMRI examination room - Take off monitors - Provide the lunch - Executive function testing - Musculoskeletal assessments	60 min	

Appendix H – Diary Process Analyses Energy Expenditure Calorimeter Study

2014
March/April, Training session 1 and 2 (approx. 2 hours) whole room calorimeter by Technician
May, Technician noticed restriction in gas samples, fixed in a day, pilot study with one child, I ordered and replaced Nitrogen and Span gas bottles.
June, pilot study with 5 yr old
August – December, instability in O2 analysers, fuse blow, exhaust fan failed, unable to go ahead with data collection until fixed by Technician.

2015
February – December, data collection (26 participants), before every participant, I arrived 1 hour earlier to calibrate all gasses before entering the chamber.
April – June, I ordered and calibrated new gas bottles, bugs in software, Technician trying to solve software problem.
December, Flow meter Chamber 2 unstable

2016
January/February, I decided, with confirmation of the Technician, to change to Chamber 1 for last 3 participants due to failed flow meter, instability in the O2 sampling in Chamber 2 and a rise in a sample gas humidity.
February, finished data collection (29 participants)
March, tests needed to be done to confirm the time constant in chamber 2 for the software, this involved sitting in the chamber for 4 hours (5 sessions).
April – I contacted engineer Paul Schoffelen and Dr.Guy Plasqui (Maastricht University, NL) for help with calculating the energy expenditure.

2017
September, visit to Maastricht University (NL) to meet with Paul Schoffelen about the energy expenditure

2018
February, I performed a methanol burn, send data to Paul
Feb - July, process of trying to calculate energy expenditure based on results from methanol burn.
August, confirmation data not reliable

Appendix I - Ethics Approval Intervention Chapter 6

UNIVERSITY OF WOLLONGONG AUSTRALIA

APPROVAL LETTER
In reply please quote: HE16/023
Further Information Phone: 4221 3386

16 March 2016
Faculty of Social Sciences
School of Education

Dear Miss Ellis,

Thank you for your response dated 11/03/16 to the HREC review of the application detailed below. I am pleased to advise that the application has been approved.

Ethics Number:	HE16/023
Project Title:	The feasibility, acceptability, and potential efficacy of a childcare-based intervention to reduce sitting time among pre-schoolers: the Standing Pre-Schools Project
Researchers:	Miss Yvonne Ellis, Professor Tony Okely, Dr Steven Howard, Dr Dylan Cliff
Documents Approved:	Initial Application 27/01/16
	Participant Information Sheet for Parents Version 2
	Participant Information Sheet for Educators Version 2
	Consent form for Parents Version 3
	Consent Form for Educators Version 2
	Interview Questions Version 1
	Observation Checklist Version 1
	Educators Checklist Version 1
Approval Date:	15 March 2016
Expiry Date:	14 March 2017

The HREC has reviewed the research proposal for compliance with the *National Statement* and approval of this project is conditional upon your continuing compliance with this document.

Approval by the HREC is for a twelve month period. Further extension will be considered on receipt of a progress report prior to expiry date. Continuing approval requires:

- The submission of a progress report annually and on completion of your project. The progress report template is available at http://www.uow.edu.au/research/ethics/human/index.html. This report must be completed, signed by the researchers and the appropriate Head of Unit, and returned to the Research Services Office prior to the expiry date.
- Approval by the HREC of any proposed changes to the protocol including changes to investigators involved
- Immediate report of serious or unexpected adverse effects on participants
- Immediate report of unforeseen events that might affect continued ethical acceptability of the project.

Ethics Unit, Research Services Office
University of Wollongong NSW 2522 Australia
Telephone (02) 4221 3386 Facsimile (02) 4221 4338
Email: rso-ethics@uow.edu.au Web: www.uow.edu.au

If you have any queries regarding the HREC review process, please contact the Ethics Unit on phone 4221 3386 or email rso-ethics@uow.edu.au.

Yours sincerely,

Associate Professor Melanie Randle
Chair, UOW & ISLHD Social Sciences
Human Research Ethics Committee

The University of Wollongong/ Illawarra and Shoalhaven Local Health Network District (ISLHD) Social Science HREC is constituted and functions in accordance with the NHMRC National Statement on Ethical Conduct in Human Research.

Appendix J - Information sheet and consent form parents Chapter 6

Standing Pre-schools Project

The feasibility, acceptability, and potential efficacy of a childcare-based intervention to reduce sitting time among pre-schoolers

Information Sheet for Parents

Dear Parent

Full details about the project, it's purpose, the researchers involved and what is required of your child, should you agree for your child to be involved, are provided in this information sheet.

What is the purpose of this study?
Research by UOW's ESRI among 300 young children from 11 childcare services in the Illawarra indicated that pre-schoolers spent almost half of their time at childcare sitting. Excessive and prolonged sitting may be detrimental to the healthy growth and development of young children. It is not known if making simple modifications to the pre-school environment may result in lower levels of sitting and more favourable developmental outcomes for children, and whether educators can feasibly implement these modifications in a childcare setting.

The aim of this study is to investigate the effects of the intervention on 3-5 year-old children's sitting time during childcare and their executive function.

What we are asking your child to do?
The childcare service that your child attends has agreed to be involved in this study. Given that your child is enrolled in this childcare service and is between 3 and 5 years-of-age, they have the opportunity to participate.

The participating services will be randomly places in one of two groups i) the intervention group, which will involve services implementing modifications for 3 months after baseline data has been collected or ii) the control group, which will involve services implementing modifications for 3 months later than intervention group.

The intervention focuses on activities that will break up sitting time. The educators will be trained to deliver the intervention over a 3-month period. Over these 3-months educators at the childcare will provide opportunities for children to participate in modified activities and routines that promote standing and moving, such using standing desks, taking the chairs away, activity breaks during story time.

Data will be collected at your child's service for 1 week at the start of the study (baseline) and 1 week at the end of the study (post-test). While your child is in childcare a trained female research assistant will take a measurement of your child's height and weight. In addition your child will participate in three activities, presented as electronic tablet games, to assess their executive function. This will be done to examine how these areas of cognitive development are influenced by changes in sitting time during childcare.

Your child will also be asked to wear a small lightweight activity monitor (called an activPAL) whilst at childcare. The activity monitors are worn on the upper thigh secured using a velcro garter that we have specially made for young children, or through the ActivPal monitor being attached to the child's thigh using a dual layer of Hydro Gel (which is similar to a bandaid) as recommended by the manufacturer.
This activity monitor allows us to measure the amount of time children spend sitting throughout the day, as well as their standing and stepping time. The activity monitor will be fitted by childcare staff or a trained female research assistant. The device will be fitted when your child arrives at their childcare service and then removed before they leave at the end of the day. Your child will be asked to wear the monitor over a one-week period when they are in childcare.

What are the benefits and risks involved in this study?
Pre-schoolers, typically the most active group in the population, spend more then 50% of their waking hours sitting. Replacing sitting with light-intensity activity may benefit their health and may have other benefits such as improved cognitive development. Intervening early will hopefully reduce young children's risk of increased sedentary time. This study will benefit your child's childcare service by providing examples of modified activities and routines that can be used to promote children's development and health through increasing standing and moving.

There are no risks associated with this study. The activity monitor is small and lightweight. The sticky to attach the activPAL on the thigh may be uncomfortable to remove. It is not painful to wear nor intrusive.

Participation in the study
You and your child are free to discontinue participation at any time. Discontinuation of your or your child's involvement will not jeopardise your or your child's current or future relationship with your early childhood service or with the University of Wollongong.

What will happen to the information that you provide?
All information collected during this study will be kept strictly confidential and be stored in a locked office. Data will be used in publications such as papers, conference presentations and grant applications, however your identity, your child's identity and that of your early childcare service will be kept strictly confidential.

Who is conducting the study?
- Professor Tony Okely, Professorial Fellow, Early Start Research Institute, University of Wollongong
- Ms Yvonne Ellis, PhD student, Early Start Research Institute, University of Wollongong
- Dr. Steven Howard, Lecturer, Early Start Research Institute, University of Wollongong
- Dr, Dylan Cliff, Research Fellow, Early Start Research Institute, University of Wollongong

If you are happy for your child to participate in this study, please complete the attached consent form and return it to the Director of your early childcare service on your child's next day of attendance.

Kind Regards,

PhD candidate Yvonne Ellis
Early Start Research Institute
Faculty of Education
University of Wollongong
yge019@uowmail.edu.au
+61 2 4221 5486

If you have any questions regarding the study, please contact PhD student Yvonne Ellis on (02) 4221 5486. If you have any concerns or complaints regarding the way the research is or has been conducted, you can contact the Complaints Officer, Human Research Ethics Committee, University of Wollongong on (02) 4221 4457 or by email (rso-ethics@uow.edu.au).

Your co-operation in this project will be greatly appreciated.

Standing Pre-schools Project

The feasibility, acceptability, and potential efficacy of a childcare-based intervention to reduce sitting time among pre-schoolers

Consent form for parents on behalf of their child

Research conducted by Prof Tony Okely, Dr Dylan Cliff, Dr Steven Howard and Miss Yvonne Ellis

I have been given information about the study entitled: "Standing Pre-schools Project" and have had the opportunity to discuss the study with Yvonne Ellis

All children aged between 3 and 5 years, who attend childcare at least once a week, are invited to participate.

I understand that if I consent for my child to participate they will be asked to complete the following assessments twice throughout the study:

- Wear an activity monitor on their thigh whilst at childcare during the week of Monday (date) to Friday (date) 2016.
- Participate in three games to measure their cognitive development
- Have their height and weight assessed by a trained female research assistant
- Provide demographic information of family/child
- Participate in activities that are focused on reducing sitting at childcare

I have been advised of the potential risks and burdens associated with this study. I understand that my participation and my child's participation is voluntary and that I and/or my child are free to withdraw from the study at any time. Withdrawal from the study will not affect my relationship or that of my child's, with our childcare service or with the University of Wollongong now or in the future. Furthermore, I understand that the information provided may be used in papers, conferences presentations or future grant applications.

If I have any enquires about the study, I can contact Yvonne Ellis on 4221 5486 or if I have any concerns or complaints regarding the way the study is or has been conducted, I can contact the Complaints Officer, Human Research Ethics Committee, University of Wollongong on +61 2 42215486. Or by email on (rso-ethics@uow.edu.au).

By signing below I am indicating my consent for my child to participate in this study as it has been described to me in the information sheet and in discussion with Yvonne Ellis. Can you please return this form on your child's next day of attendance. Your co-operation in this study will be greatly appreciated

CONSENT

I (your name) ___________________________________

agree for my child (**child's full name**) ____________________________

to take part in the study entitled

"The feasibility, acceptability, and potential efficacy of a childcare-based intervention to reduce sitting time among pre-schoolers: the Standing Pre-Schools Project"

Parent Surname: ___________________________________

Parent Given name: ___________________________________

Child's Date of Birth: _____________________________(dd/mm/yyyy)

Sex of the Child: ___________________________________(male/female)

Address: ___________________________________

Postcode: ___________________________________

Phone: (H)___________________________________

(M)___________________________________

Email: ____

Signature: ____

Date: ___________________________________

Name of Childcare Centre:____.

What is your **highest** level of schooling?

☐1 No formal qualifications

☐2 Year 10 or equivalent (e.g. School Certificate)

☐3 Year 12 or equivalent (e.g. Higher School Certificate)

☐4 Trade/apprenticeship/certificate (e.g. hairdresser, chef, plumber)

☐5 Diploma (e.g. Business/Accounting)

☐6 University Degree

☐7 Post-graduate qualification (e.g. Graduate Diploma, Masters, PhD)

Appendix K - Information sheet director and educators Chapter 6

Standing Pre-schools Project

The feasibility, acceptability, and potential efficacy of a childcare-based intervention to reduce sitting time among pre-schoolers

Information Sheet for Directors and Educators

Dear Director/Educator,

Full details about the project, it's purpose, the researchers involved and what is required of your child, should you agree for your child to be involved, are provided in this information sheet.

What is the purpose of this study?
Research by UOW's ESRI among 300 young children from 11 childcare services in the Illawarra indicated that pre-schoolers spent almost half of their time at childcare sitting. Excessive and prolonged sitting may be detrimental to the healthy growth and development of young children. It is not known if making simple modifications to the pre-school environment may result in lower levels of sitting and more favourable developmental outcomes for children, and whether educators can feasibly implement these modifications in a childcare setting.

The aim of this study is to investigate the effects of the intervention on 3-5 year-old children's sitting time during childcare and their executive function.

Methods and demands on educators
The study will be introduced to educators at a time that is convenient for the childcare service (eg staff meeting). Participating childcare services will be randomized to either a control or intervention after baseline data is collected. Services involved in the intervention will have the opportunity for additional information about the delivery of the intervention strategies, the control schools will be given the opportunity to benefit from these strategies once all data collection is complete (at the end of the study). The intervention will introduce a number of strategies to encourage pre-schoolers to sit less and stand or move more during the day by breaking up or reducing sitting time. Examples of the measures that will be implemented include using standing desks and introducing breaks in sitting time. Throughout the intervention, Ms Ellis will evaluate the strategies with the educators (e.g. staff meetings) to assess the success of the intervention implementation.

All educators involved in the intervention will receive information on methods to incorporate standing activities into their classroom.

Once parents provide consent, participating children will be asked to complete several assessments. They will be asked to wear an activPAL inclinometer (worn on the leg) during their time at childcare over the course of a week. Height and weight data will also be collected on the first day and will be used to calculate body mass index (BMI). The fitting of the devices on the first day and measurement of BMI will take approximately an hour. Children will also be asked to complete some iPad games to test Executive Function (EF) tests on day one and two. The tests will take approximately 20 minute per child. All of the measures will be taken at the start of the study and again after 3 months.

Possible risks, inconveniences and discomforts
During data collection (monitoring and executive function tests) there might be a mild interruption to daily tasks. For children, apart from the inconvenience of wearing the devices and the time it takes to collect the data, which would be less than three hours of their time during the initial contact and less than three hours 3 months later, we can foresee no risks for the participants. Their involvement in the study is voluntary and they may withdraw participation from the study at any time. Refusal to participate in the study will not affect their relationship with the University of Wollongong.

Benefits of the research
Pre-schoolers, typically the most active group in the population, spend more then 50% of their waking hours in sedentary behaviour. Replacing sitting with light-intensity PA may also benefit their health and may have other benefits such as improved executive function. Intervening early will hopefully reduce young children's risk of increased sedentary time.
This study will benefit your child's childcare service by providing information about the effects of a reduced sitting time on your child's executive function. It will furthermore provide a basis for future decisions on the development of daily routines for educators/directors. In addition, the cognitive games provide children with valuable thinking and learning experiences.

What will happen to the information that you provide?
All information collected during this study will be kept strictly confidential and be stored in a locked office. Data from the activity monitors maybe used in publications such as papers, conference presentations and grant applications, however your identity, your child's identity and that of your early childcare service will be kept strictly confidential.

Who is conducting the study?
- Professor Tony Okely, Professorial Fellow, Early Start Research Institute, University of Wollongong
- Ms Yvonne Ellis, PhD student, Early Start Research Institute, University of Wollongong
- Dr. Steven Howard, Lecturer, Early Start Research Institute, University of Wollongong
- Dr, Dylan Cliff, Research Fellow, Early Start Research Institute, University of Wollongong

If you are happy for your child to participate in this study, please complete the attached consent form and return it to the Director of your early childcare service on your child's next day of attendance.

Kind Regards,

PhD candidate Yvonne Ellis
Early Start Research Institute
Faculty of Education
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If you have any questions regarding the study, please contact PhD student Yvonne Ellis on (02) 4221 5486. If you have any concerns or complaints regarding the way the research is or has been conducted, you can contact the Complaints Officer, Human Research Ethics Committee, University of Wollongong on (02) 4221 4457 or by email (rso-ethics@uow.edu.au).

Your co-operation in this project will be greatly appreciated.

Appendix L - Training sessions 1, 2 and 3 - Chapter 6

EARLY START UNIVERSITY OF WOLLONGONG

The Standing Pre-schools Project

An intervention for reducing sitting time in pre-schoolers at Childcare

Manual for educators

Training session 1 – The standing desk

University of Wollongong 2016

Contents

The Standing Pre-school Intervention

- The intervention focuses on reducing sitting, however has broader child and educator educational health outcomes
- The Standing Pre-school intervention aims to modify the process rather than the product – the educational learning outcomes for children will remain the same throughout the Jump Start approach
- It compromises 5 components

The Standing Pre-school intervention is NOT about	**The Standing Pre-school intervention IS about**
• Working as individuals	• Working together as a team
• Doing things the same way	• Meeting regularly
• Additional work, longer work hours, more administration	• Utilising time differently
• UOW telling childcare educators what to do	• Being supported and encouraged
	• Improving child and educator outcomes
	• Being intentional
	• Being engaged

	• Fun and excitement • Educators learning and growing

Why does the Standing Pre-school Intervention focus on reducing sitting time in pre-school children?

Pre-schoolers, typically the most active group in the population, spend more then 50% of their waking hours in sedentary behaviour. Replacing sitting with standing or light-intensity physical activity may also benefit to their health and may have other benefits such as improved executive function. Early childhood should be targeted as a key time to promote healthy lifestyle behaviours, and it is critically important to children's current and future health that they achieve the recommended levels of physical activity and limit sedentary behaviours during their early years of life. Intervening early will hopefully reduce young children's risk of increased sedentary time.

Results from phase I, II and III of The Standing Pre-school Project

2013 – Phase I – Sitting, standing and stepping time of young children from 11 IACC childcare services across the Illawarra.

- 49% of children's time at childcare was spent in sitting, 33% standing and 19% in PA

- Pre-schoolers have more 5-9 minute sitting bouts compared to toddlers

2013 – Phase II – Focus group – childcare educators perceptions of and solutions to reducing sitting time in young children: a qualitative study

- Childcare practices and weather were factors that influences children's sitting time at childcare
- Potential solutions to reduce sitting time were to break up sitting time by using energy breaks, standing desks, transition trains between activities, relocating key facilities around the space to promote movement, and interactive stories.
- Suggest using posters to increase awareness among children about the benefits of reducing sitting time.

2014/2015 – Phase III – Examine the acute effects of a reduced sitting day on energy expenditure, executive function and musculoskeletal health – whole room calorimeter study

- Results still in process.
- Musculoskeletal health – hamstring length and balance slightly increased on reduced sitting day

- Feasibility modified activities; children are able to do table activities standing up.

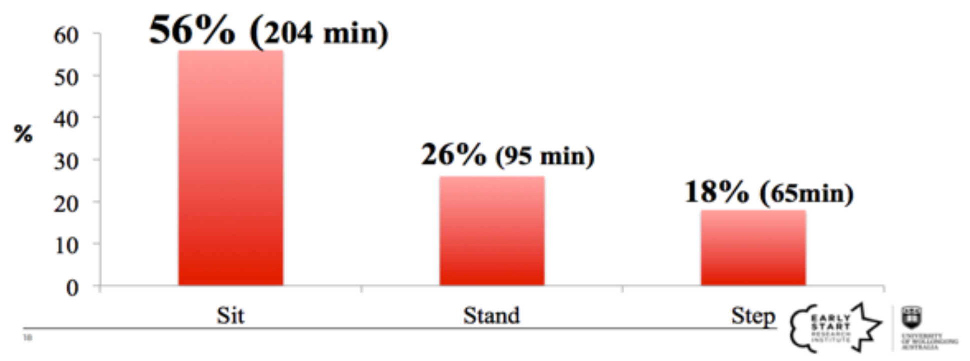
2016 – Phase IV – Establish whether an intervention to reduce sitting time in the childcare setting will result in less sitting time for children aged 4 – 5 years and to assess whether a reduction in sitting time has a positive effect on child's executive function.

Definition of executive function – this is the umbrella term for the management (regulation, control) of cognitive processes including working memory, reasoning, task flexibility and problem solving as well as planning and execution.

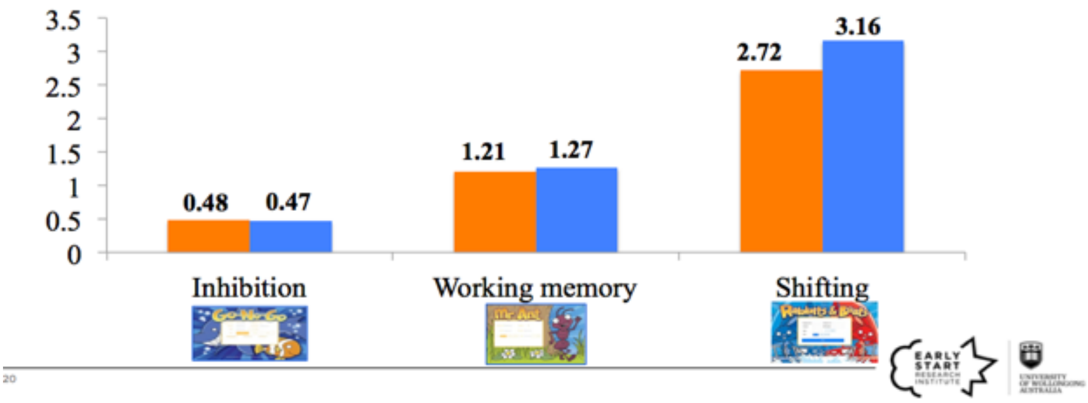
Baseline data results Keiraview:

- 35 children
- Average age = 4.13yrs
- Average wear time/day = 6hr

<u>Activity data</u>



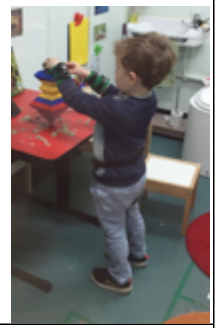
<u>Executive data</u>



- Inhibition is slightly higher compared to the norm
- Working memory with a score of 0.06 lower compared to norm
- Shifting is with a score of 0.58 lower compared to norm.

Five components of the Standing Pre-school intervention

Component 1 – Standing Desk (Table time – sitting to standing activities)

Who	All educators and children
What	Replace normal tables with standing desks.
When	Inside/outside, when children are drawing, painting, building blocks etc… During group time/table time/free play  
Why	Reducing children's sitting time, as it has shown to be positively associated with health (cognitively and physically). Prevention of health issues later in life.
How	Encourage Consistent use Make standing desks attractive by putting the play equipment on the table Take away opportunities of sitting (no chairs)

EYLF OUTCOMES	**EXAMPLES: CHILDREN**	**EXAMPLES: EDUCATORS**
<u>*Outcome 1*</u> *Children have a strong sense of identity:* • *Children develop ther emerging autonomy, interdependence, resilience and sense of agency* • *Children develop knowledgeable and confident self-identities* • *Children learn to interact with other with care, empathy and respect*	• Children celebrate their contributions and achievements with others • Children show interest in being a part of the group • Children engage with and contribute to share play experiences	Educators display delight and encouragement at children's attempts Educators support children's efforts and encourage as appropriate Educators motivate children to succeed when children are discouraged
<u>*Outcome 2*</u> *Children are connected with and contribute to their world.* • *Children develop a sense of belonging to groups and*	• Children listen, co-operate and consider others	• Educators model language that children can use to express themselves • Educators support the acquisition of listening, following directions and co-

communities and an understanding of the reciprocal rights and responsibilities necessary for active community participation. • *Children become aware of fairness*		operation skills that will allow children to contribute to group play
<u>Outcome 3</u> Children have a strong sense of wellbeing • *Children become strong in their social and emotional wellbeing* • *Children take increasing responsibility for their own health and physical wellbeing*	• Children demonstrate an enjoyment of being physically active • Children understand that part of looking after your body is to be regularly active • Children demonstrate spatial awareness and play active games and use equipment safely around others	• Educators demonstrate a value for health through integrating physical activity in an enjoyable way into the daily routine • Educators model enjoyment of activity • Educators provide opportunities for children to enjoy being physically active • Educators participate enthusiastically in physical activity with children

Outcome 4 Children are confident and involved learners • *Children develop dispositions for learning such as curiosity, cooperation, confidence, creativity, commitment, enthusiasm, persistence, imagination, and reflexivity* • *Children transfer and adapt what they have learnt from one context to another*	• Children develop the ability to mirror, repeat and practice the actions of others, either immediately or later • Children transfer knowledge from one setting to another (eg skills, rules or strategies from games)	

NQS	Standard / Element	Example
2.1	Each child's health is promoted	Standing desk improves health
2.1.1	Each child's health needs are supported	Standing desk improves health
2.2	Healthy eating and physical activity are embedded into the program	Standing desk increases light physical activity
2.2.2	Physical activity is promoted through planned and spontaneous experiences and is appropriate for each child.	Standing desk increases light physical activity
5.2.2	Each child is supported to manage their own behaviour, respond appropriately to the behaviour of others and communicate effectively to resolve conflicts	The intervention creates situations where children are called upon to follow directions, share a space, and share turns on equipment. Educators are present to support this development.
3.1.1	Outdoor and indoor spaces, buildings, furniture, equipment, facilities and resources are suitable for the purpose	The standing desk has the purpose to improve health in children.
3.2.1	Outdoor and indoor space are designed and organised to engage every child in quality experiences in both built and natural environments	The intervention is very specifically a time where educators consider how they organise their space and equipment to enable a high quality physical activity experience

		(combined with other learning areas such as maths and literacy)

The Standing Pre-school Intervention

OPTIMAL APPROACH

- Support each other and get involved. The more educators involved in implementing the approach the easier it will be.
- Have confidence in your ability to deliver the activities
- Be enthusiastic. Children will get the most out of the program if there is high educator participation and continual positive encouragement.
- Be inclusive – encourage children's involvement
- Ask questions whenever you need to
- Put systems in place to make each component a natural part of the day
- Be reflective

Implementation data

One of the ways of tracking if this is occurring is through the collection of implementation data. At the end of each day, educators need to complete the implementation data sheet.

The data collected here may seem very simple and perhaps unimportant – but this type of data is critically important so that we can assess if the standing desks are being implemented as planned.

Additionaly, it will help us identify component where additional support is required from the interventionist.

Completing this sheet will be very quick and easy – all you have to do is tick yes or no if the different component were completed.

Please see the form on the next page →.

The Standing Pre-schools Project

An intervention for reducing sitting time in Childcare

Manual for educators

Training session 2 – Stand Up Breaks & Active story time

University of Wollongong

2016

3. Stand Up Breaks

4. minute Stand Up Breaks that break up sitting time or used during transitions

Who	All educators will have the opportunity to facilitate the energy breaks
What	1 to 2 minute "stand up" music-based physical activities
When	Facilitated twice daily (start with once) • Use it as a "tool" to get the children together. Before transition start. • Before/After lunchtime
Why	• Breaking up long periods of sitting and increasing physical activity opportunities are important for both children's health and educator health. • Allows children to get their "wiggles" out • Energizes them and increases their ability to focus on the next learning activity. In order for kids to learn, they need to move.
How	Facilitated by educators using music and youtube movies provided

WK	Experience 1	Experience 2
1	Heads, Shoulders, knees & toes	Freeze – Jingle Jam
2	Shake your sillies out – Wiggles	Here we go Dorothy
3	Dance On	Hokey Pokey
4	Get you moving	Geronimo – Sheppard – Freeze
5	Move your body	Move – Little Mix – Freeze
6	Can you point your fingers	Rock around the clock – free dancing
7	Wombat Wobble	I can't wait to be king – The Lion King – Freeze
8	Action Song	Twist and Shout – free dancing
9	So many animals	Happy – Pharrell Williams – Freeze
10	Hot Potato	Roar – Katie Perry – Freeze
11	Do Do Do	Under the sea – Little Mermaid – Freeze
12	Let me see your Boogaloo	Que Sera – Justice Crew – Freeze
13	The Shimmie Shake	Shake you body – Jackson 5
14	Jump Jump Star	Ugly Girl – GRL – Freeze
15	5 Kangaroos	Call me maybe – Freeze
16	The Monkey dance	Lightning is a firework – Katie Perry – Freeze
17	If your happy and you know it	Livin La Vida Loca – Donkey and Puss in boots – Freeze
18	Old Macdonald had a farm	We're all in this together- High school Musical – Freeze
19	The animal boogie	Cha Cha slide

20	The Sid Shuffle	Usher's ABC song
21	Red, Black and Yellow	You make me feel like dancing – Wiggles
22	Funky bug hop	Let's get ridiculous – Redfoo – Freeze
23	Scoo Be Doo	We're gonna dance
24	A rooty chy cha	Shake it off – Taylor Swift – Freeze
25	Hop, Jump, Leap, Bounce	Brown Girl in the ring
26	Round the campfire tonight	I like to move it – Afro Circus – Freeze

You Tube Clips

Week	Song	You Tube Link
5a	Move your body	https://youtu.be/fhxJEyXVDmo
7a	The wombat wobble	https://youtu.be/tvFSPxL_IWA
9a	Some many animals	https://youtu.be/EMIMDIB_ABQ
12a	Let me see your boogaloo	https://youtu.be/668VcguM_-E
15a	5 Kangaroos	https://youtu.be/ZsUOqvi2b4M
19a	The animal boogie	https://youtu.be/25_u1GzruQM
20a	The Sid shuffle	https://youtu.be/uMuJxd2Gpxo
20b	Usher's ABC Song	https://youtu.be/SWvBAQf7v8g
24a	A rooty chy cha	https://youtu.be/SALCPlmRUeo

Key points to remember

- **Stand Up Breaks activities should be facilitated once a day.**
- **Make sure that music is ready**
- **The children will only be as enthusiastic as the educators**
- **Stand Up Breaks is about improving child and educator outcomes**

5. Active Story Time

Book	How to increase physical activity
The Hungry Caterpillar	Ask the children to move like a caterpillar, in ways they can remember from the story e.g.: popping out of the egg, going into a cocoon and emerging as a butterfly.
Where the wild things are	Ask the children to pretend they are the trees of the forest growing in Max's bedroom. Then they could pretend to be in the row boat. The children could dance the wild rumpus before getting back in the boat, sailing back to his room.
Blossom Possum	Ask the children to act out the story, going on an outback adventure.
Aliens love underpants	Ask the children to pretend they are in a spaceship – zoom around. Ask them how they think aliens might move – wobbly arms, legs, head.
Wombat Stew	Divide the children into small groups and ask the to pretend to be the bush animals dancing around the bubbling billy as an educators chants/sings the rhymes.
Books about different modes of transport (e.g.: On the road)	Ask the children to pretend they are driving different modes of transport shown in the book e.g.: digger – the children's arms could be the arm/scoop of the vehicle moving dirt.
Bears don't bounce	Ask the children to act out how the animals should not, and then should, behave as told in the story.
Possum in the house	After reading the story ask the children to stand up as it is read a second time. This time each time phrases are read, the children move in different ways e.g.: 'Help help' the children can throw their arms in the air repeatedly, 'Oh drat' – stomp their feet and 'screech screech' – Jump up and down.
The little mouse, the red ripe strawberry and the big hungry bear	Ask the children to climb a ladder like the mouse did in the story and pretend to pick a strawberry. The children could pretend to be the hungry bear stomping through the forest, be the mouse on guard duty and pretend to gobble the strawberry up. Maybe a game like Captains coming (jump in skill activity) could be made up.
Boris Monster	The children could carry out the ballet moves as depicted in the book.
Giraffes can't dance'	Children hop up and dance every time one of the animals dances

We are going on a Bear Hunt'	Children could stand up and act out the actions
The Very Hungry Caterpillar	Use technology to look at how caterpillars move and then encourage the children to move like a caterpillar.
The Magic Hat	Children could move like the hat, the toad, baboon, kangaroo, giraffe or the wizard.
Rumble in the Jungle	Children could move like the monkeys, lions, or elephants

Additional Examples

Experience	How to increase physical activity
Space	Dance to the song 'The Rocket Ship' by Rainbow, Trees and Tambourines.
Literacy	Have a basket of objects or pictures for each letter of the alphabet. Ask the children to choose an object/picture and then jump, hop, march to the cards and place the object on its starting letter. Ask the children to move their bodies into the shape of different letters. Dance to Usher's ABC song on the Jump Up CD (track 40).
Transition	Instead of clapping the syllables of children's names to move them off to the next area, ask the children to stomp out the syllables.
Farm Animals	Sing and move to 'Old MacDonald had a farm' and 'Ponies' by The Wiggles.
Musical Chairs	Use music that is energetic, upbeat and encourage the children to dance and move to the music, finding a chair when it pauses.
Gardening	Use technology to watch how a seed germinates and goes through different stages of growth. Ask the children to re-in-act this. Have the children carry out yoga poses such as the 'Tree' and 'Flower Blossoming'.
Colours	Have hoops and coloured beanbags set up in a large space. Ask the children to toss the beanbags in to hoops of the same colour, matching them up.
Action songs	The Bear Went Over the Mountain Old MacDonald had a Farm (move like animals as well as sounds) Incy Wincy Spider Galoomp Went the Little Green Frog Dinosaur Stomp Twinkle Twinkle Wheels on the Bus (move around)

	If you're happy and you know it (jump around, dance about…)

Key points to remember

- **Active story time should be facilitated at least twice a week**
- **Through focuses on modifying the process not the outcome**
- **Preparation is the key to success**
- **Active story time will look and feel different for each childcare centre**
- **Engage with children during the learning experiences.**

The Standing Pre-schools Project

An intervention for reducing sitting time in Childcare

Manual for educators

Training session 3 – lunch and nap time

University of Wollongong

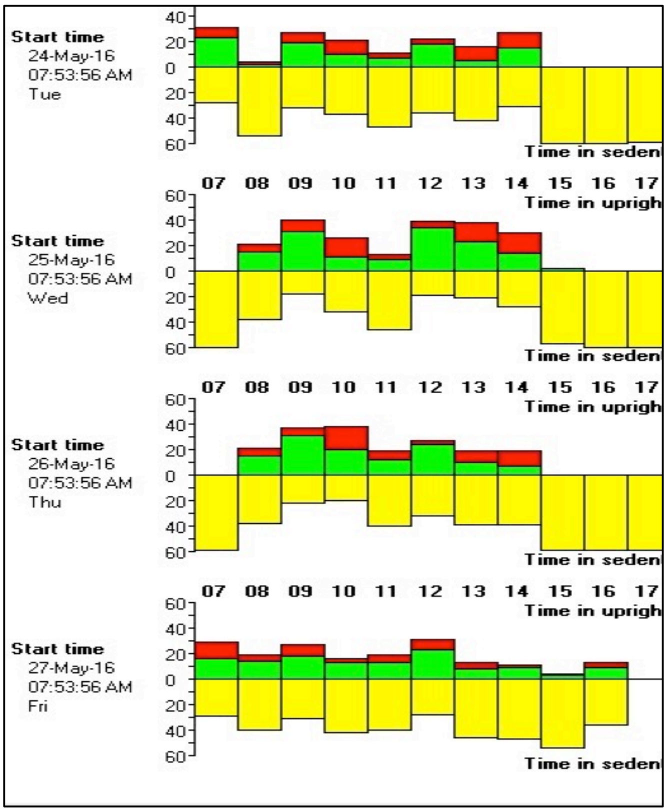
2016

1. Meal times

Results focus groups 11 centers

–*"Children spent large proportion of their time sitting to eat lunch followed by story time followed by relaxation and they do quiet activities which is generally always at the table – predominantly sitting down."*

–*"Children could be sitting up to an hour due to cultural differences. Children are required to eat certain foods during lunch from their parent."*



Above picture shows the output of the ActivPAL from one child of this centre. Yellow is sitting, green is standing and red is stepping.

Most of the sitting time occurs during meal times (between 11am and 12pm).

2. Break up sitting time during meal times

- Placement of the bin
    - Place the bin from the table or a few meters from where the children are sitting, therefore they will need to walk to throw away waste.

- Children can get their own drink/water bottle
    - Place the bottles on another table, therefore children will have to stand up to get their own drink

- Energy break or play outside before or after
    - Implement a 2 minute energy break or play outside before or after they have meal time

- Smaller groups during morning tea, 4 or 5 children at each table.
    - Have smaller groups at the table, this way other children can still play and come at the table as soon as one of the children is done.

3. Rest time


ELSEVIER

Early Childhood Research Quarterly

Volume 29, Issue 4, 4th Quarter 2014, Pages 660–668

Emotional Climate and Behavioral Management during Sleep Time in Early Childhood Education Settings

Cassandra L. Pattinson, Sally L. Staton, Simon S. Smith, Dominique M. Sinclair, Karen J. Thorpe

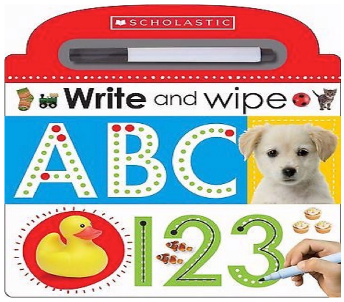
71% did not sleep during the designated sleep period.

Quotes Focus Groups

"Rest and relaxation is a time where the children are sedentary for a long period. Parents want the children to have that rest time"

"Quiet time is where the children need to calm down which usually involves sitting"

4. Reduce sitting time during rest time



1. **Replace sitting activities with quiet activities at the standing table, such as reading and writing.**
2. **Stretching or yoga**

Key points to remember

- **Placement of bin during meal times**
- **Placement of water bottles**
- **Energy break or play outside before mealtimes**
- **Smaller groups during meal times**

- **Replace rest activities normally sitting/lying down with quiet activities at standing table, stretching or yoga.**

Appendix M - Observation list

Standing Pre-schools Project – Observation list

Service:____________________________ Week:________________________ Name:	Monday Date __________	Tuesday Date _______	Wednesday Date _________	Thursday Date ____________	Friday Date ___________
Table time – Standing desk					
Where the standing desks used? (Y/N)					
Did educators encourage children to use the standing desk? (Y/N)					
Were they used in the morning and afternoon? (Y/N)					
What kind of activities did they do on the standing desk?					
Did all the children make use of the standing desk? (Y/N)					
If not, how many used the standing desk?					
What was the length of the activity at the standing desk? (min)					
Was the easel used? (Y/N)					
How many children used the easel?					

Comments____

____

____

Appendix N - List of publications or under review

1. Ellis, Y. G., Cliff, D. P., Janssen, X., Jones, R. A., Reilly, J. J. & Okely, A. D. (2016) Sedentary Time, Physical Activity and Compliance with IOM Recommendations in Young Children at Childcare. *Preventive Medicine Reports,* 7, 221-226

2. Ellis, Y.G., Cliff, D.P., Okely, A.D. (2017) Childcare educator's perceptions of and solutions to reducing sitting time in young children: a qualitative study. *Early Childhood Education Journal, 46*(4), 377–385

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Appendix O - Authors' Contribution

1. Yvonne Ellis conducted data collection, manipulation and analyses and drafted the manuscript. Dr. Dylan Cliff, Dr. Xanne Janssen, Dr. Rachel Jones, Professor John Reilly, Professor Anthony Okely were involved in the development of the research questions and the design of the study. All authors contributed to the interpretation of data and were involved in the writing and critically revising of the manuscript. All authors read and approved the final manuscript.

2. Yvonne Ellis wrote the manuscript, conducted the data collection, analyses ad interpretation. Dr. Dylan Cliff and Professor Anthony Okely were involved in the design of the study. All authors contributed to the interpretation of data and were involved in the writing and critically revising of the manuscript. All authors read and approved the final version.

3. Yvonne Ellis wrote the manuscript, performed the experiments, analyses and interpretation, and contributed to the development of the study design. Dr. Dylan Cliff, Professor Anthony Okely and Dr. Steven Howard secured the funding. Yvonne Ellis, Dr. Dylan Cliff and Professor Anthony Okely and designed the experiments. All authors reviewed and approved the final manuscript.

4. Yvonne Ellis wrote the manuscript, conducted the data collection, analysis and interpretation, and contributed to the development of the original study design. Dr. Dylan Cliff, Professor Anthony Okely and Dr. Steven Howard contributed to the development of the study design, supervised drafting of the manuscript, and reviewed it for important intellectual content.

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